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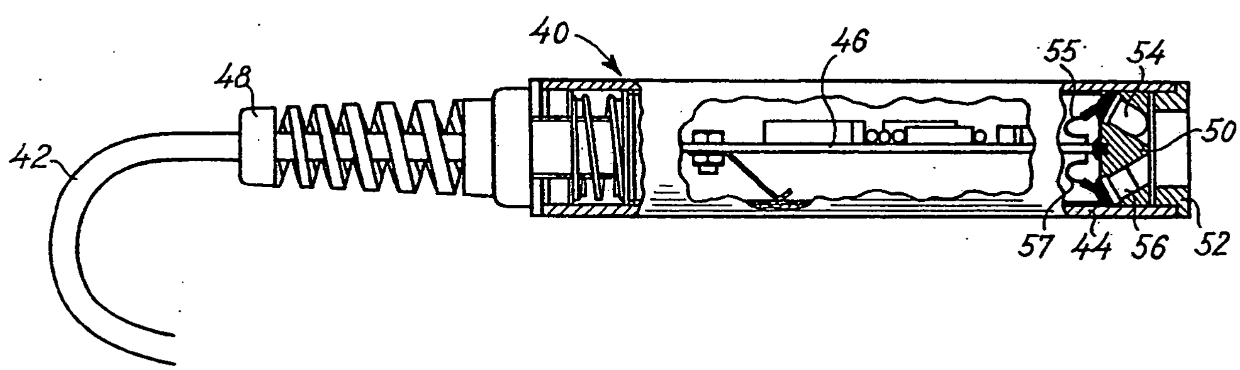

(57) Abstract

A method and an apparatus for determining an individual's ability to become tanned or to stand exposure to ultraviolet radiation without causing a skin reaction, such as skin cancer or erythema. According to the method, at least part of said individual's skin surface is exposed to electromagnetic radiation of first and second wavelengths and of predetermined intensities. The first and second wavelengths at which erythrodermic skin reflection is high and low, respectively. The intensity of electromagnetic radiation reflected from the individual's skin surface is measured so as to determine first and second coefficients of reflection of said first and second wavelengths, respectively. The first and second coefficients are compared to sets of coefficients of reflection representing coherent sets of coefficients of reflection of specific states of redness, and the first and second coefficients of reflection are corrected into a set of corrected first and second coefficients of reflection of a specific state of redness. The corrected first coefficient of reflection is further converted into a measure representing the individual's ability to become tanned or to stand exposure to ultraviolet radiation without causing said skin reaction.

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A method and an apparatus for determining an individual's ability to stand exposure to ultraviolet radiation.

The present invention relates to the technique of determining an individual's ability to become tanned or to stand exposure to ultraviolet radiation without causing a skin reaction, such as skin cancer or erythema, which technique is described in US Patent No. 4.882.598, to which US Patent reference is made, and which US Patent is herewith incorporated in the present specification by reference.

According to the technique described in the above US Patent, the individual's ability to become tanned or to stand exposure to ultraviolet radiation without causing a skin reaction may be determined by exposing a skin surface part of the individual to electromagnetic radiation, e.g. visible light, and determining the coefficient of reflection of the individual's skin surface part to the electromagnetic radiation and converting the coefficient of reflection to a measure representing the individual's ability to become tanned or to stand exposure to ultraviolet radiation. The technique described in the above US Patent is based on clinical experiments revealing a linear relationship between a number of individuals coefficients of skin surface reflection in logarithmic representation and the same individuals' ability to stand exposure to ultraviolet radiation of a predetermined intensity and of a predetermined spectral composition. According to the above-mentioned US Patent, individuals who are erythrodermic or erythematous may further be identified by performing the determination of the individuals' coefficient of reflection to electromagnetic radiation at two distinct wavelengths, one of which is a wavelength at which erythrodermic skin reflection is high, and another one of which is a wavelength at which erythrodermic skin reflection is low.

The basis of the present invention is the realization that the determination of the individual's coefficient of reflection or reflections to electromagnetic radiation is to a high degree influenced by the blood flow of the individual at the site or the skin surface part at which the measurement is carried out. An obvious solution solving the problem of eliminating the blood flow influence on the determination of the measure representing the individual's ability to become tanned or to stand exposure to ultraviolet radiation in accordance with the teaching of the above US Patent is to specify a "normal" measuring routine involving that the individual is kept in a normalized position and state, e.g.

specifying the site or the part of the individual's skin surface at which the measurement is to be performed, the position of the site or skin surface part in question, and the position of the individual and further a specific increased or reduced blood flow accomplished through an occlusion of a body part of the individual, on which body part the site or skin surface part is positioned, or alternatively a state of extreme blood flow, e.g. provoked through heating the site or the skin surface part at which the measurement is to be performed. In numerous instances, the individuals cannot be maintained in a normalized position and state corresponding to the above specified circumstances or similar relevant specified circumstances for numerous reasons. Also, a so-called normalized state may often result in an extreme variation of the measuring results obtained, which makes the overall measuring technique unreliable and inadequate.

An object of the present invention is to provide a method of determining an individual's ability to become tanned or to stand exposure to ultraviolet radiation without causing a skin reaction, which method is independent of the blood flow of the individual, and which method renders it possible to provide a measure representing said individual's ability independent on the blood flow of the individual.

A further object of the present invention is to provide a method of determining an individual's ability to become tanned or to stand exposure to ultraviolet radiation, which method produces normalized measuring results which are readily comparable, rendering it possible to obtain a high degree of reproducibility of the determination.

A further object of the present invention is to provide an apparatus for determining an individual's ability to become tanned or to stand exposure to ultraviolet radiation, which apparatus is capable to perform a measuring routine and generate a measuring result independent of the blood flow of the individual, the ability of which is to be determined.

A still further object of the present invention is to provide an apparatus of the above type of an extreme reliability and producing measuring results of high reproducibility and high accuracy.

According to a first aspect of the present invention, a method of determining an individual's ability to become tanned or to stand exposure to ultraviolet radiation without causing a skin reaction, such as skin cancer or erythema, comprising the following steps:

exposing at least part of said individual's skin surface to

electromagnetic radiation of a first wavelength and of a predetermined intensity, said first wavelength being a wavelength at which erythrodermic skin reflection is high,

measuring the intensity of electromagnetic radiation reflected from said part of said individual's skin surface so as to determine a first coefficient of reflection of said skin surface part to said electromagnetic radiation of said first wavelength,

exposing said skin surface part to electromagnetic radiation of a second wavelength and of a predetermined intensity, said second wavelength being a wavelength at which erythrodermic skin reflection is low,

measuring the intensity of electromagnetic radiation reflected from said part of said individual's skin surface part so as to determine a second coefficient of reflection of said skin surface part to electromagnetic radiation of said second wavelength,

comparing said first and second coefficients of reflection with sets of coefficients of reflection representing coherent sets of coefficients of reflection of said first and second wavelengths of specific states of redness so as to determine said individual's skin surface part's state of redness, converting said first and second coefficients of reflection into a set of corrected first and second coefficients of reflection of a specific state of redness, so as to determine said individual's skin surface part's coefficients of reflection of said first and second wavelengths at a specific state of redness, and

converting said corrected first coefficient of reflection into a measure representing said individual's ability to become tanned or to stand exposure to ultraviolet radiation without causing said skin reaction.

Basically, in accordance with the teaching of the present invention, it has been realized through clinical investigations that the first and the second coefficients of reflection determined in accordance with the teaching of the above US Patent may be converted to a set of corrected first and second coefficients of reflection of a specific state of redness since the first and the second coefficients of reflection at different states of redness, and consequently different blood flows, fulfil specific mathematic relations, as will be evident from the description below, rendering it possible to convert a set of first and second coefficients of reflection to a set of corrected first and second coefficients of reflection of a specific state of redness. Preferably,

according to the teaching of the present invention, the specific state of redness to which the first and second coefficients of reflections measured in accordance with the method according to the present invention and in accordance with the teaching of the above US Patent corresponds to an average zero blood flow state, i.e. a state in which the individual's blood flow is zero or extremely low, eliminating to any substantial extent the influence of the redness of the individual on the coefficients of reflection.

According to a further realization according to the teaching of the present invention, the method advantageously further comprises the step of determining the individual's skin surface part's degree of pigmentation from the corrected first and second coefficients of reflection of the first and second wavelengths at the specific state of redness.

The basic clinical investigations on which the present invention is based have revealed that provided the coefficient of reflection of said second wavelength is represented in logarithmic representation, the mathematic relation through which sets of coefficients of reflection representing coherent sets of coefficients of reflection of said first and second wavelengths are linearly related, rendering the conversion of the first and the second coefficients of reflection into a set of coherent first and second coefficients of reflection extremely simple and readily adaptable to automatized conversion, e.g. by means of a computer, such as a microprocessor.

In accordance with a second aspect of the present invention, an apparatus is provided for determining an individual's ability to become tanned or to stand exposure to ultraviolet radiation without causing a skin reaction, such as skin cancer or erythema, comprising:

a first electromagnetic source for generating electromagnetic radiation of a first wavelength and of a predetermined intensity and for directing said electromagnetic radiation of said first wavelength to a part of said individual's skin surface so as to expose said part of said individual's skin surface to said electromagnetic radiation of said first wavelength,

a second electromagnetic source for generating electromagnetic radiation of a second wavelength and of a predetermined intensity and for directing said electromagnetic radiation of said second wavelength to said part of said individual's skin surface so as to expose said part of said individual's skin surface to said electromagnetic radiation of said

second wavelength,

a light-detecting means for measuring the intensity of electromagnetic radiation reflected from said part of said individual's skin surface,

a measuring means connected to said light-detecting means for measuring the intensity of electromagnetic radiation reflected from said part of said individual's skin surface so as to determine a first and a second coefficient of reflection of said skin surface part to said electromagnetic radiation of said first and second wavelength, respectively,

a comparison and converting means connected to said measuring means for comparing said first and second coefficients of reflection with sets of coefficients of reflection representing coherent sets of coefficients of reflection of said first and second wavelengths of specific states of redness so as to determine said individual's skin surface part's state of redness, for converting said first and second coefficients of reflection into a set of corrected first and second coefficients of reflection of a specific state of redness, so as to determine said individual's skin surface part's coefficients of reflection of said first and second wavelengths at a specific state of redness, and for converting said corrected first coefficient of reflection into a measure representing said individual's ability to become tanned or to stand exposure to ultraviolet radiation without causing said skin reaction.

Basically, the apparatus according to the present invention may be implemented in accordance with the above embodiments of the method according to the present invention. Furthermore, according to a first embodiment of the apparatus, separate light detector means for detecting electromagnetic radiation of the first and the second wavelengths, respectively, may be provided. Preferably, the apparatus according to the present invention, however, comprises a single light-detecting means constituted by a single light detector, first of all simplifying the structure of the apparatus and secondly ensuring that the reflection of light of the first and the second wavelength is generated at one and the same part of the individual's skin surface and further eliminates any difference in sensitivity and consequently measuring accuracy between the measurement of the reflection of electromagnetic radiation of the first and the second wavelength.

Due to the high accuracy of the measuring technique according to

the present invention, the UV treatment of e.g. psoriasis patients may be adapted so as to carry out a full-body scanning of the body of the patient for carrying out an optimum UV treatment of the entire body of the patient, at which treatment, any differences as to UV sensitivity of different skin surface areas of the patient are complied with, so that, independent of the difference in UV sensitivity of the differnet skin surface areas of the patient, any skin surface area of the patient is exposed to an optimum UV treatment.

The present invention will now be further described with reference to the drawings, in which

Fig. 1 is a diagram illustrating the correspondence between the coefficient of skin surface reflection and the wavelength of the electromagnetic radiation, to which the skin surface part has been exposed, further illustrating a curve A illustrating the response of an average, non-sun-tanned and non-erythrodermic skin surface part of an individual and a curve B illustrating the response of an erythrodermic or sun-burnt skin surface part of an individual,

Fig. 2 is a diagram illustrating the correspondence between the coefficient of skin surface reflection and the wavelength of the electromagnetic radiation, to which the skin surface part has been exposed, further illustrating the same curve A as shown in Fig. 1 and a curve C illustrating the response of a non-erythrodermic and extremely pigmented skin surface part of an individual,

Fig. 3 is a diagram illustrating the linear relationship between the logarithmic representation of a number of individuals' coefficients of skin surface reflection and the individuals' ability to stand exposure to ultraviolet radiation of a predetermined intensity and of a predetermined specific spectral composition,

Fig. 4 is an overall schematic and perspective view of an apparatus implemented in accordance with the teaching of the present invention,

Fig. 5A is an overall schematic and partly cut-away view of a photodetector constituting a component of the apparatus shown in Fig. 4,

Figs. 5B and 5C are elevational views of an optic guide and light diode and light detector supporting component of the photodetector shown in Fig. 5A.

Fig. 6 is a diagram illustrating the relation between measurements carried out on a total of 49 individuals, further illustrating the correspondence between the coefficient of reflection to red light and the

coefficient of reflection to green light in logarithmic representation in dependency of the blood flow,

Fig. 7 is a diagram similar to the diagram shown in Fig. 6, from which diagram an individual's corrected coefficient of reflection to red light and the same individual's pigmentation may be determined from a set of measuring results and related to a specific state of redness,

Fig. 8 is a diagram similar to the diagrams of Figs. 6 and 7, illustrating the relation between the coefficient of reflection to red light and the coefficient of reflection to green light in logarithmic representation of individuals of different degrees of redness caused by ultraviolet radiation,

Fig. 9a is a diagram illustrating the relation between the correspondence between the corrected coefficient of reflection to red light in logarithmic representation of individuals and the UV dose in B-MED of the same individuals,

Fig. 9b is a diagram illustrating the relation between the correspondence between the pigment% and the UV-dose in B-MED of the same individuals,

Fig. 10 is a diagram illustrating the linear correspondence between clinically evaluated redness of individuals and the degree of redness of the same individuals,

Fig. 11 is a circuit diagram of the electronic circuitry of the apparatus shown in Fig. 4,

Fig. 12 A and B are circuit diagrams of a microprocessor block of the electronic circuitry shown in Fig. 11,

Fig. 13 is a circuit diagram of the electronic circuitry of the photodetector shown in Fig. 5,

Fig. 14 is a diagram illustrating the linear relation between laser-induced skin changes of individuals subjected to laser treatment and the degree of pigmentation of the same individuals,

Fig. 15A-15L are diagrams further illustrating the correspondence between the laser-induced effects and the degree of pigmentation of the individuals exposed to laser treatment,

Fig. 16 a diagram illustrating the linear relationship between individuals' basic MEDs after UV treatment and the degree of pigmentation of the same individuals,

Fig. 17 is a diagram illustrating the difference between an experimentally found dose and a calculated dose to reach a certain degree of

redness, and

Fig. 18 is a diagram illustrating the difference of an individual's sensitivity to UV treatment compared to a normal sensitivity.

According to the present invention, non-invasive measuring techniques for measuring pigmentation and redness of a skin surface part of an individual are provided. Basically, the present invention constitutes a refinement or improvement of the technique described in US Patent No. 4.288.598, to which US Patent reference is made and which US Patent is herewith incorporated in the present specification by reference. According to the non-invasive measuring technique according to the above US Patent and according to the present invention, a conversion from pigmentation to UV-sensitivity is established and an objective measurement of pigmentation and redness is provided, which objective measurement may be converted into UV-sensitivity of the individual in question. According to the teachings of the present invention, phototherapy and photochemotherapy during treatment is adjustable so as to optimize the treatment of an individual at all times, taking into due consideration the action spectra for phototherapy and photochemotherapy.

The basic teachings of the present invention are based on the below described measurements.

Spectrophotometric measurements of the reflection of skin surface parts of individuals were carried out within the wavelength area 260 nm - 800 nm. A laboratory system comprising a 150 W Xenon arc lamp (manufactured by Zeiss, FRG) was used irradiating the entrance slit of a single grating monochromator (manufactured by Jobin-Yvon H20, France, 200 nm focal length, f/3.5). An 8 nm band-pass filter was used for all measurements. From the exit slit of the monochromator the light beam was directed to the skin surface part of an individual via one branch of a fused silica bifurcated fiber optic cable (manufactured by Oriel, Stratford, CT, USA). Said one branch of the fiber optic cable was held perpendicular to the skin surface part at a distance of 5 mm by means of a spacer device. The other branch of the fiber optic cable was used for directing the radiation reflected from the skin surface part to a calibrated multiprobe (manufactured by EG & G 550 - 2) connected to a radiometer (manufactured by EG & G 550, Salem, MA, USA). The measurements were performed at every second nm from 260 nm to 800 nm using the reflection from a calcium carbonate plate as the 100% reflection reference at all wavelengths. On the basis of the measurements, spectra

were recorded, and calculations based on the measurements were performed by a HP computer (manufactured by Hewlett Packard, Palo Alto, CA, USA).

A total of 22 individuals were used for recording reflection spectra, which 22 individuals had different skin complexion. Within the skin surface areas of the 22 individuals within which skin surface areas the measurements were performed, the MED (Minimum Erythema Dose for an individual person 24 h after exposure) was determined using the radiation from a Solar Simulator (manufactured by Solar Light Company, Philadelphia, PA, USA). Spots of a diameter of 1 cm were irradiated, and the redness of the skin surface parts was classified as one MED when minimal redness had clearly demarcation lines to the surrounding non-irradiated skin.

For all 22 individuals, spectra were recorded from closely spaced minimally pigmented and pigmented areas. A comparison of these spectra showed that the best discrimination between the curves was between 507 nm and 512 nm.

In Fig. 1, a diagram is shown illustrating the correspondence between the coefficient of skin surface reflection and the wavelength of the electromagnetic radiation, to which the skin surface part has been exposed and illustrating a curve A representing the response of an average non-sun-tanned and non-erythrodermic skin surface part of an individual and a curve B representing the response of an erythrodermic or sun-burned skin surface part of an individual. The maximum difference between the curves A and B was between 503 nm and 512 nm for all individuals.

In Fig. 2, a diagram similar to the diagram of Fig. 1 is shown, comprising the curve A also shown in Fig. 1 and further a curve C representing the response of a non-erythrodermic and extremely pigmented skin surface part of an individual. The maximum difference between the curves A and C was between 503 and 512 nm.

In Fig. 3 a diagram is shown, which diagram corresponds to the diagram shown in Fig. 1 in US Patent No. 4.882.598, and which diagram illustrates the linear relationship between the coefficient of reflection to light of a wavelength of 510 nm in logarithmic representation and the time to reach 1 MED using the Solar Simulator recorded for a total of 26 individuals.

On basis of the measuring results illustrated by the curves A, B, and C shown in Figs. 1 and 2, it is concluded that redness influences

the measurements of pigmentation when wavelengths between abt. 380 nm to abt. 600 nm are used. Also the valleys corresponding to the absorption of hemoglobin (abt. 540 - 580 nm) are clearly observed. Reflection within the wavelength area 540 - 580 nm is consequently to be used for estimating redness of the skin and wavelengths above approx. 600 nm and below approx. 380 nm should be used for estimating pigmentation as measurements at these wavelengths are to no substantial extent affected by redness.

Consequently, light sources to be chosen for this purpose are e.g. light-emitting diodes with peak wavelengths at 550 nm (Green) and 660 nm (Red).

A unique measuring probe comprising two light-emitting diodes emitting light of the above wavelengths was designed, which measuring probe is shown in Fig. 5 and is to be discussed in greater detail below.

A further experiment involving 49 volunteers with different pigmentation was made, which experiment revealed relations between the skin surface reflection of red light and green light, which relations constitute the basic realization of the present invention.

In order to investigate in what way redness of the skin influences the estimation of pigmentation, the following test was conducted:

For the above-mentioned 49 individuals green reflection and red reflection were recorded on the antebrachium both on the volar side and on the dorsal side, provided the skin surface of the individual was not too hairy. A total of four situations were tested in one and the same spot ensuring a constant pigmentation. The four situations were: Zero flow, the arm in vertical position, the arm in horizontal position, and a situation in which reactive redness was generated after Zero flow. Zero flow was obtained by pressing all blood out of the arm using elastic bandage followed by obstruction of the blood flow by a cuff on the upper arm. In all cases, the individual was lying in a horizontal position and the skin changes were monitored until the changes had stabilized.

Fig. 6 is a diagram in which the coefficient of skin reflection to red light and the skin reflection to green light in logarithmic representation are listed for all 49 individuals. From the measuring results, it is first of all verified that the coherent sets of skin surface reflection to red light and skin surface reflection to green light in logarithmic representation of the four above listed situations are positioned along straight lines A, B, C, and D, respectively, having a com-

mon intercept at 1.54 at the ordinate axis. The slope of the curve A representing the average Zero flow was deduced from the diagram being 0.03977, and the slope of the straight line D representing the reactive redness situation was also deduced from the diagram being 0.03247. The straight lines B and C representing the vertical and the horizontal position of the arm of the individual, respectively, had slopes in between the slopes of the straight lines A and D. For one and the same individual, the pigmentation should be considered constant in all four situations, and the red reflection should consequently be identical in all four situations. This is, however, not the case. The test revealed that the measurements corresponding to the above described four situations, i.e. corresponding to the straight lines A, B, C, and D, performed on a single individual could be presented by a straight line which, however, was not a vertical line in the diagram shown in Fig. 6. Examples of the straight line corrections are shown in Fig. 6 which straight lines connect points on the Zero flow line and the corresponding points on the lines B, C, and D corresponding to the above described situations. On the basis of the straight line correction, any set of measuring results representing the skin surface reflection to red and the skin surface reflection to green in logarithmic representation may be, so to speak, normalized as far as redness is concerned by correcting the measuring results to a normalized or standard situation, e.g. a Zero flow situation.

In Fig. 6, a straight dotted line O is also shown, representing the average Zero flow plus 2 SD (Standard Deviation) corresponding to a slope of 0.0427, including 95% of the Zero flow measurements. By converting any measuring results representing the skin surface reflection to red and the skin surface reflection to green in logarithmic representation to the straight, dotted line O, the best possible correction for redness of the skin for calculating the pigmentation may be performed, as will be evident from the discussion below with reference to Fig. 7. An extremely white individual exhibit a skin surface reflection to red of 70% which is consequently named 0% pigmentation, whereas 100% pigmentation corresponds to 0% skin surface reflection to red.

In Fig. 7, redness and pigmentation of a specific individual are calculated on the basis of skin surface reflection measurements to red and green light, the skin surface reflection to green light being presented in logarithmic representation. Thus, Fig. 7 is a diagram, the ab-

scissa and ordinate axes of which are identical to the abscissa and ordinate axes of the diagram shown in Fig. 6. The straight line correction discussed above of the measuring results generated by measuring the coefficients of skin surface reflecction to red and green light of an individual and by converting the green light skin surface reflection coefficient into logarithmic representation is performed along a dotted line C, so to speak transforming the measuring results represented by the point P to a point P′ of the line O, i.e. the line intercepting the ordinate at 1.54 and having a slope of 0.0427. The abscissa of the point P′ represents the corrected red reflection coefficient and also the pigmentation degree represented in a percentage varying from 0% to 100% as indicated in Fig. 7. Consequently, a specific degree or state of redness for different individuals of different pigmentation is represented by a straight line of constant slope intercepting the ordinate at 1.54. Thus, the degree or state of redness of an individual is readily measurable on the basis of the diagram shown in Fig. 7, as a specific degree or state of redness corresponds to a specific straight line intercepting the ordinate at 1.54 and having a specific slope.

In Fig. 8, a diagram similar to the diagrams shown in Figs. 6 and 7 is shown, representing lines representing different degrees of redness caused by ultraviolet radiation exposed to individuals having different pigmentation. The lines intercept the ordinate axis at 1.54 like the straight lines shown in Figs. 6 and 7. The highest degree of redness corresponding to 100% redness is chosen to include individuals having naevus flammeus of very dark-bluish red colour and corresponds to a straight line of a slope of 0.015.

Table 1 below illustrates the correspondence between clinical redness as defined below, redness percentage and the read-out from an apparatus to be described below with reference to Fig. 4 and implemented in accordance with the teachings of the present invention.

Table 1:

Clinical Redness	Redness %	Display Reading
0	<29.6	<30
(+)	32.7	33
+	37.4	37

++	43.9	44
+++	51.6	52

Zero redness corresponds to the highest UV dose of Philips TL12 tubes, which dose may be given before redness appears.

(+) redness corresponds to faint, spotted redness without a clear demarcation to the surrounding, non-irritated skin surface areas.

+ redness corresponds to faint redness with a clear demarcation to the surrounding skin surface areas.

++ redness corresponds to clear redness with slight edema to be felt in the tissue.

+++ redness corresponds to heavy redness with edema to be felt or seen above the surrounding skin surface areas.

The measurements were made after having irradiated the 49 individuals on the buttocks with different doses of UV from Philips TL12 lamps. The doses used were in B-MED (Basic Minimal Erythema Dose being 312 J/m^2 at 296 nm. ((24 h erythema) Parrish). 24 h after irradiation, the redness degree was estimated by means of the above listed "+" system.

In Fig. 9a, a diagram is shown, illustrating the correspondence between the corrected coefficient of reflection to red and the UV dose in B-MED to reach different levels of erythema. Since all curves exhibit a common intercept at the ordinate axis, a common equation may be deduced which can be used to predict the treatment dose, taking into consideration the degree of pigmentation of the skin surface part in question and further what level of redness is to be produced 24 h after irradiation. The equation used is: Treatment time = 24.2 + (0.1709 x specific redness - 5.668) x ln KR (corrected coefficient of reflection to red) x number of seconds to reach a B-MED (the intensity of the light source). The sensitivity of a specific skin surface area of the individual's body relative to the tested part of the buttocks has to be taken into consideration when predicting the treatment dose.

The curves shown in Fig. 9a are almost parallel, and further calculations, according to which calculations the correspondence between the UV dose in B-MED is related to the degree of pigmentation, have proven that dose versus pigmentation may also be used to predict the treatment time. In this case, the additional dose to shift from UV reaction of 0 to +, from + to ++, and from ++ to +++ were identical and independent of

pigmentation (0.69 B-MED). Under these circumstances, the equation is: Treatment time = (-0.206 + 0.689 x ord. redness (ord. means prescribed) + 0.0829 x pigmentation) x the number of seconds to reach a B-MED (the intensity of the light source).

In Fig. 9b, a diagram is shown, illustrating the correspondence between pigmentation% and the UV-dose in B-MED to reach different levels of erythema. Since all curves are parallel, the curves shown in Fig. 9b are preferably used instead of the curves shown in Fig. 9a, thus substituting the curves shown in Fig. 9a in calculations similar to the above calculations.

The redness "plus" system may be converted into specific figures or numbers as illustrated in Fig. 10, which illustrates the relation between estimated redness and the degree or state of redness in % measured in accordance with the present invention and represented by straight lines.

In Fig. 4 an overall perspective view of an apparatus according to the present invention is shown, which apparatus is designated the reference numeral 10 in its entirety. The apparatus 10 comprises a housing 12 defining a sloping top surface 14 in which a display 16 is arranged together with a 2-digit thumb wheel switch 18 and a 4-digit thumb wheel switch 20. The top surface 14 is further provided with a recess in which a photodetector 40 to be described in greater details below with reference to Fig. 5 is received in the idle mode of the apparatus. The photodetector 40 is connected to the electronic circuitry of the apparatus 10 through a multicore cable 42. The apparatus 10 is a mains supplied apparatus and is consequently provided with a mains cable 22 and a mains plug 24. The electronic circuitry of the apparatus 10 is to be described in greater details below with reference to Figs. 11, 12A, 12B, and Example 1.

In Fig. 5A, a schematic and partly cut-away view of the photodetector 40 is shown. The photodetector 40 comprises a cylindrical housing 44 in which a printed circuit board 46 is received, which printed circuit board includes the electronic circuitry of the photodetector 40, which electronic circuitry is to be described in greater details below with reference to Fig. 13 and Example 1. The electronic circuitry of the printed circuit board 46 is connected to the multicore cable 42 which extends from the left-hand end of the cylindrical housing 44 through a coiled bushing 48. At the opposite, right-hand end of the cylindrical

housing 44, a light guide and light-emitting diode supporting and light detector supporting component 50 is received, supported in a fixed position relative to the right-hand end of the photodetector 40 by means of an annular support component 52. In Fig. 5A, a light-emitting diode 54 and a light detector 56 are illustrated received within the component 50 and connected to the printed circuit board 46 through conductors 55 and 57, respectively.

In Figs. 5B and 5C, the component 50 is shown in greater details from the left-hand side and the right-hand side, respectively, relative to the position of the component 50 within the cylindrical housing 44 shown in Fig. 5A. From Figs. 5B and 5C, it is evident that a total of three apertures are provided extending through the component 50 for receiving two light-emitting diodes, one of which emits red light and one of which emits green light, and a light detector. The through-going apertures of the component 50 are designated the reference numerals 60, 62, and 64, respectively. The through-going apertures 60, 62, and 64 are geometrically spaced so as to minimize the risk that any false light may influence the light reflection measurement to be carried out by means of the photodetector 40 in accordance with the teaching of the present invention and also in accordance with the teaching described in the above-mentioned US Patent No. 4.882.598. The apertures 60, 62, and 64 are further arranged in a specific angular and sloping relation so as to obtain an optimum light transmission path from the light-emitting diodes to the light detector from a reflecting surface and further so as to eliminate any light scattering effects from light scattering surfaces, which light scattering might erroneously influence the measurement to be carried out by means of the photodetector 40 and the apparatus 10 according to the present invention, to which apparatus the photodetector 40 is connected.

In Fig. 11, an overall circuit diagram of the electronic circuitry of the apparatus 10 implemented in accordance with the teaching of the present invention is shown. The electronic circuitry is in its entirety designated the reference numeral 100. The electronic circuitry 100 basically comprises the following sections, a mains supply section 102, a photodetector input section 104, an A/D (Analog/Digital) converter section 106, a central microprocessor section or block 108, and an interface section 110 through which interface section, the sections 102, 104, 106, and 108 are connected to one another and further interfaced to the

display 16, the 2-digit thumb wheel switch 18, the 4-digit thumb wheel 20, and a printer output port 112.

The components of the electronic circuitry 100 are listed in the below Example 1.

In Fig. 12, an overall circuit diagram of the microprocessor section or block 108 is shown, which microprocessor block is implemented by an electronic circuit of the type MCS 52, manufactured by the Danish company Circuit Design. The individual components of the microprocessor block or section 108 are listed in the below Example 1.

In Fig. 13, a circuit diagram of the electronic circuitry of the printed circuit board 46 of the photodetector 40 is shown. The individual components of the electronic circuitry 46 are listed in the below Example 1.

<u>Example 1</u>

The electronic circuitry 100 of the apparatus 10 implemented in accordance with the teaching of the present invention was constructed from the components identified in Fig. 11.

The microprocessor block or section 108 of the electronic circuitry 100 was implemented by a circuit of the type MCS-52 supplied by the Danish company Circuit Design. The electronic components of the circuit diagram shown in Fig. 12 were:

R1	4.7	kohm
R2-R4	10	kohm
R5	47	ohm
R6	10	kohm
R7	1	kohm
R8	10	kohm
R9-R11	1	kohm
R12	10	kohm
R13	220	ohm
R14	10	kohm
R15	1	kohm
R16	150	kohm
R17	10	kohm
R18	47	kohm
R19	470	kohm

R20	100 kohm
R21-R22	10 kohm
R23	47 ohm
R24	4.7 kohm
R25-R28	10 kohm
R29	4.7 kohm
R30	1 kohm
C1	100 uF
C2-C3	100 nF
C4	220 uF
C5	47 pF
C6-C9	22 uF
C10	100 uF
C11-C12	22 pF
C13	22 pF
C14-C15	100 uF
C16-C25	100 nF
C26-C28	470 pF
C29	1 uF
D1	1N4148
D2	red LED
D3	IN4148
D4-D6	IN4148
TI	BC547
T2	BC557
T3-T4	BC547
T5	BC557
T6-T7	BC547
T8	BC640
XI	7.3728 MHz
X2	32 kHz
LI	150 uH

ICI	80C31
IC2	74HC573
IC3	27C64(27C256)
IC4	74HC138
IC5	74HC133
IC6	PAL16L8
IC7	74HC573
IC8	55257
IC9	27C64(27C256)
IC10	MAX232
IC11	MAX630
IC12	M3002
IC13	74HC00
IC14	82C55
IC15	74HC573
IC16	74HC541
IC17	74HC573
IC18	74HC541
IC19	PALI6L8

The photodetector 40 was constructed from the components identified in Fig. 13.

The apparatus according to the present invention fulfilled the below technical specifications:

Light source	
LED green	550 nm peak value
LED red	660 nm peak value
Power Requirements	
Power	220 V
Dimensions	
Weight	kg
Height, length and depth	71x234x272 mm
Environment	
Ambient Temperature	17 - 28°C
Humidity	40 - 80% RH
Max. variability between measurements under standardized conditions	
On brown tile:	
Green LED	0,2%
Red LED	0,3%
On white standards:	
Green LED	0,3%
Red LED	0,6%
Max. interapparatus variability	+/- 2,5% on skin
Measuring time (from 1st to last beep)	-4,5 sec

Example 2

The microprocessor of the microprocessor section or block 108 of the apparatus according to the present invention was operated by means of the programme listed in Table 2 or alternatively operated by means of the programme listed in Table 3. This programme is working in the same way as the programme listed in Table 2 but is giving a warning when the patient is read instead of recalculation of the dose. That allows the operator or the doctor to decide if any reduction in treatment time should be performed.

Provided the 2-digit thumb wheel is set to 15, the number of joules/sqcm will be calculated for PUVA-treatment (- 300 + 2200 x ord.

redness (ord. means prescribed) + 205 x pigment%). This dose should come from a Philips TL 09 lamp or a lamp with a similar spectral distribution. Likewise, it is possible to have the treatment dose in joule or m joules/sqcm for different lamp types when the thumb wheel to the left in Fig. 4 is set to 1-13. 14 is the code used when only pigment protection factor, skin redness, and skin pigmentation is to be shown on the display.

Table 2:

```
10     REM 25.1.1992 PRG2.BAS
20     REM 100% refl=900 mV
30     REM FFE7H=65511=CONTROLREG.
40     REM FFE6H=65510= C-PORTE
50     REM FFE5H=65509= B-PORTE.
60     REM FFE4H=65508= A-PORTE.
70     BAUD 2400 :  REM BAUDRATE TIL DISPLAY
80     XBY(65511)=145 :  REM A INPUT,B OUTPUT,C-LOW INPUT,C-HI OTPUT
90     GOSUB 2010
100    GOSUB 2030
110    PRINT #"
120    JUMPER=XBY(65508).AND.128 :  IF JUMPER=0 THEN 2140
130    FOR P=0 TO 5
140    XBY(65509)=2**P
150    SW(P)=XBY(65510).AND.15
160    NEXT P
170    SW2=1000*SW(3)+100*SW(2)+10*SW(1)+SW(0) :  REM S/MED FOR KILDEN
180    SW1=10*SW(5)+SW(4)
185    ORD=SW1*.1 :  REM ORDINERET 24H ROD (1 DECIMAL)
190    IF SW2=0 THEN 1630
200    XBY(65510)=0 :  REM DIODES OFF
210    F=0 : SB=0
220    N=0
230    GOSUB 640
240    IF M(N)>100 THEN 130
250    IF SW1>30 THEN 300
260    GOSUB 2010
270    GOSUB 2030
280    PRINT #"
290    GOTO 340
300    GOSUB 2010
310    GOSUB 2050
320    PRINT #"
330    GOTO 130
340    N=N+1
350    IF N<3 THEN 230
360    XBY(65509)=128 :  REM PB7=LYDGIVER ON
370    FOR T=0 TO 10 :  NEXT T
380    XBY(65509)=0 :  REM PB7=LYDGIVER OFF
390    XBY(65510)=16 :  REM PC4 HI GREEN DIODE ON.
400    FOR T=0 TO 200 :  NEXT T
410    FOR N=0 TO 4
420    GOSUB 640
430    G(N)=M(N)
440    NEXT N
450    XBY(65509)=128
460    FOR T=0 TO 10 :  NEXT T
470    XBY(65509)=0
480    XBY(65510)=0 :  REM  DIODES OFF
490    FOR T=0 TO 200 :  NEXT T
500    FOR N=0 TO 4
510    GOSUB 640
520    S(N)=M(N)
530    NEXT N
540    XBY(65509)=128
550    FOR T=0 TO 10 :  NEXT T
```

```
560  XBY(65509)=0
570  XBY(65510)=64 :  REM PC6 HI RED DIODE ON.
580   FOR T=0 TO 200 :  NEXT T
590   FOR N=0 TO 4
600   GOSUB 640
610  R(N)=M(N)
620   NEXT N
630   GOTO 830
640   DO
650  I=XBY(65508) : C=I.AND.112
660   UNTIL C=112 :  REM I.E.PA6,PA5 OG PA4 HI.
670   DO
680  I=XBY(65508) : C=I.AND.112
690   UNTIL C=48 :  REM  I.E. PA6 LO I.E. HUNDREDS SELECTED.
700  H=I.AND.15
710   DO
720  I=XBY(65508) : C=I.AND.112
730   UNTIL C=96 :  REM I.E. PA4 LO I.E. UNITS SELECTED.
740  U=I.AND.15
750   DO
760  I=XBY(65508) : C=I.AND.112
770   UNTIL C=80 :  REM I.E. PA5 L I.E. TENS SELECTED.
780  T=I.AND.15
790  FT=1
800   IF H=10 THEN H=0 : FT=-1
810  M(N)=FT*(100*H+10*T+U)
820   RETURN
830  XBY(65509)=128 : XBY(65510)=0
840   FOR T=0 TO 100 :  NEXT T
850  XBY(65509)=0
860  GMIN=1000 : SMIN=1000 : RMIN=1000
870  GMAX=0 : SMAX=0 : RMAX=0
880  GS=0 : SS=0 : RS=0
890   FOR N=0 TO 4
900  GS=GS+G(N) : SS=SS+S(N) : RS=RS+R(N)
910   IF G(N)<GMIN THEN GMIN=G(N)
920   IF G(N)>GMAX THEN GMAX=G(N)
930   IF S(N)<SMIN THEN SMIN=S(N)
940   IF S(N)>SMAX THEN SMAX=S(N)
950   IF R(N)<RMIN THEN RMIN=R(N)
960   IF R(N)>RMAX THEN RMAX=R(N)
970   NEXT N
980   IF GMAX-GMIN>40 THEN F=1
990   IF SMAX-SMIN>10 THEN F=1
1000  IF RMAX-RMIN>40 THEN F=1
1010 RG=.1*INT((GS-SS)/4.5)
1020 RR=.1*INT((RS-SS)/4.5)
1030  IF RG<5 THEN F=1
1050  IF F=1 THEN 1180
1100 GI=LOG(RG)-1.54 :  REM ln(RG)-intercept
1110 SL=GI/RR :  REM slope
1120 KR=RR+17.5*(1-SL/.0427) :  REM KORR. RED REFL.
1130 KGI=.0427*KR :  REM KORR GR REFL
1150  IF KR=0 THEN F=1
1160  IF KR<0 THEN F=1
1170  IF F=0 THEN 1350
```

```
1180  GOSUB 2010
1190  GOSUB 2070
1200  GOSUB 2090
1210  FOR T=0 TO 600 :  NEXT T
1220  GOTO 90
1350 PMT=100*(70-KR)/70 :  IF PMT<0 THEN PMT=0
1360 REDN=100*(.0427-SL)/.0277 :  IF REDN<0 THEN REDN=0
1365  IF PMT>60 THEN SB=1
1370 PMT=INT(PMT)
1380 REDN=INT(REDN)
1390  PRINT #CHR(27),"I",CHR(17),CHR(22),
1400  PRINT #" PIGMENTATION ",PMT,"%"
1405  IF SB=1 THEN  PRINT #" REDNESS UNRELIABLE " :  GOTO 1420
1410  PRINT #" REDNESS      ",REDN,"%"
1420  FOR T=0 TO 1500 :  NEXT T
1430 PP=24.2-5.4971*LOG(KR) :  REM PIGM.BESK.FAKTOR
1440 PP=.1*INT(10*PP)
1450  PRINT #CHR(27),"I",CHR(17),CHR(22),
1460  PRINT #" PIGMENT PROTECTION"
1465  IF PP>.5 THEN 1470
1467  PRINT #"       UNRELIABLE    "
1468  FOR T=0 TO 1500 :  NEXT T
1469  GOTO 90
1470  PRINT #" FACTOR ",PP
1480  FOR T=0 TO 1500 :  NEXT
1485 ARD=16.97-491.5*SL :  REM  ACTUELL REDNESS
1487  IF PMT>60 THEN 1500
1490  IF REDN>29.6 THEN 1510
1500 TT=.5*(24.2+(.1709*ORD-5.668)*LOG(KR))*SW2 :  GOTO 1520
1510 TT=.1709*(ORD-ARD)*LOG(KR)*SW2
1520  PRINT #CHR(27),"I",CHR(17),CHR(22),
1530 TT=INT(TT) :  IF TT<0 THEN TT=0
1540 H=INT(TT/3600)
1550 M=INT((TT-3600*H)/60)
1560 S=TT-M*60-H*3600
1570  PRINT #"    TREATMENT TIME "
1580  IF H=0 THEN 1600
1590  PRINT #"   ",H,"HOUR",M,"MIN" :  GOTO 1622
1600  IF M=0 THEN 1620
1610  PRINT #"   ",M,"MIN ",S,"SEC    " :  GOTO 1622
1620  PRINT #"       ",S,"SEC     " :  GOTO 1622
1622  FOR T=0 TO 1500 :  NEXT T
1624  GOTO 120
1630  PRINT #CHR(27),"I",CHR(17),CHR(22),
1640  PRINT #"*CALIBRATE*   PLACE"
1650  PRINT #"DETECTOR ON STANDARD"
1660 XBY(65509)=1
1670 SW=XBY(65510).AND.15 :  IF SW>0 THEN 10
1680 XBY(65509)=2
1690 SW=XBY(65510).AND.15 :  IF SW>0 THEN 10
1700 XBY(65509)=4
1710 SW=XBY(65510).AND.15 :  IF SW>0 THEN 10
1720 XBY(65509)=8
1730 SW=XBY(65510).AND.15 :  IF SW>0 THEN 10
1740  FOR T=0 TO 1000 :  NEXT T
1750 XBY(65510)=32
```

```
1760  FOR T=0 TO 200 :  NEXT T
1770  GOSUB 640
1780 S=M(N)
1790  IF S>40 THEN 1630
1800 XBY(65510)=48
1810  FOR T=0 TO 200 :  NEXT T
1820  GOSUB 640
1830 G=M(N)
1840 GP=.1*INT((G-S)/.9)
1850 XBY(65509)=128
1860  FOR T=0 TO 5 :  NEXT T
1870 XBY(65509)=0
1880  PRINT #CHR(27),"I",CHR(17),CHR(22),
1890  PRINT #GP,"%", TAB (9),"GREEN      "
1900 XBY(65510)=96
1910  FOR T=0 TO 200 :  NEXT T
1920  GOSUB 640
1930 R=M(N)
1940 XBY(65510)=32
1950 RP=.1*INT((R-S)/.9)
1960 XBY(65509)=128
1970  FOR T=0 TO 15 :  NEXT T
1980 XBY(65509)=0
1990  PRINT #RP,"%", TAB (9),"RED        "
2000  GOTO 1660
2010  PRINT #CHR(27),"I",CHR(17),CHR(22),
2020  RETURN
2030  PRINT #"    *** READY ***   "
2040  RETURN
2050  PRINT #" CHECK DOSE SETTING"
2060  RETURN
2070  PRINT #"ERROR  ERROR  ERROR"
2080  RETURN
2090  PRINT #" REPEAT MEASUREMENT"
2100  RETURN
2110  REM ***
2120  REM ***
2130  REM ***
2140  REM TESTPG FOR HUDREFLEKTANSMETER.TEST.BAS
2150  REM *** INITIALISERING
2160  REM 100% refl=900 mV
2170  REM FFE7H=65511=CONTROLREG.
2180  REM FFE6H=65510= C-PORTE
2190  REM FFE5H=65509= B-PORTE.
2200  REM FFE4H=65508= A-PORTE.
2210  BAUD 2400 :  REM BAUDRATE TIL DISPLAY
2220 XBY(65511)=145 :  REM A INPUT,B OUTPUT,C-LOW INPUT,C-HI OUTPUT
2230  PRINT #CHR(27),"I",CHR(17),CHR(22),
2240  REM *** INIT SLUT
2250  PRINT #"TESTER LYDGIVER"
2260  FOR N=0 TO 1
2270 XBY(65509)=128
2280  FOR T=0 TO 50 :  NEXT T
2290 XBY(65509)=0
2300  FOR T=0 TO 50 :  NEXT T
2310  NEXT N
```

```
2320 PRINT #" TESTER OMSKIFTERE"
2330 DIM SW(6)
2340 FOR P=0 TO 5
2350 XBY(65509)=2**P
2360 SW(P)=XBY(65510).AND.15
2370 NEXT P
2380 FOR P=5 TO 4 STEP -1
2390 PRINT #SW(P),
2400 NEXT P
2410 PRINT #"  ",
2420 FOR P=3 TO 0 STEP -1
2430 PRINT #SW(P),
2440 NEXT P
2450 PRINT #
2460 SW2=1000*SW(3)+100*SW(2)+10*SW(1)+SW(0)
2470 SW1=10*SW(5)+SW(4)
2480 IF SW2=0 THEN 2500
2490 GOTO 2340
2500 PRINT #CHR(27),"I",CHR(17),CHR(22),
2510 PRINT #"  A/D-CONV.UDG. mV"
2520 GOSUB 2750
2530 PRINT #"  ",M, TAB (10),"          "
2540 PRINT #""
2550 XBY(65509)=1 : SW(0)=XBY(65510).AND.15
2560 IF SW(0)=1 THEN 2600
2570 IF SW(0)=2 THEN 2670
2580 GOTO 2520
2590 GOTO 2520
2600 XBY(65510)=16 :  REM PC4 HI GREEN DIODE ON.
2610 FOR T=0 TO 200 :  NEXT T
2620 GOSUB 2750
2630 XBY(65510)=0 :  REM  DIODES OFF
2640 PRINT #"  ",M, TAB (10),"GREEN    "
2650 PRINT #""
2660 GOTO 2550
2670 XBY(65510)=64 :  REM PC6 HI RED DIODE ON
2680 FOR T=0 TO 200 :  NEXT T
2690 GOSUB 2750
2700 XBY(65510)=0 :  REM   DIODES OFF
2710 PRINT #"  ",M, TAB (10),"RED      "
2720 PRINT #""
2730 GOTO 2550
2740 REM ***AFLAESNING AD A/D-CONVERTER
2750 DO
2760 I=XBY(65508) : C=I.AND.112
2770 UNTIL C=112 :  REM I.E.PA6,PA5 OG PA4 HI.
2780 DO
2790 I=XBY(65508) : C=I.AND.112
2800 UNTIL C=48 :  REM  I.E. PA6 LO I.E. HUNDREDS SELECTED.
2810 H=I.AND.15
2820 DO
2830 I=XBY(65508) : C=I.AND.112
2840 UNTIL C=96 :  REM I.E. PA4 LO I.E. UNITS SELECTED.
2850 U=I.AND.15
2860 DO
2870 I=XBY(65508) : C=I.AND.112
```

```
2880  UNTIL C=80 :  REM I.E. FA5 L I.E. TENS SELECTED.
2890  T=I.AND.15
2900  FT=1
2910  IF H=10 THEN H=0 : FT=-1
2920  M=FT*(100*H+10*T+U)
2930  RETURN
2940  REM *** AFLAESNING SLUT
```

Table 3:

```
10      REM 18.1.1993 PRG2.BAS MOD TIL SPEC3.BAS
20      REM 100% refl=900 mV
30      REM FFE7H=65511=CONTROLREG.
40      REM FFE6H=65510= C-PORTE
50      REM FFE5H=65509= B-PORTE.
60      REM FFE4H=65508= A-PORTE.
70      BAUD 2400 :  REM BAUDRATE TIL DISPLAY
80      XBY(65511)=145 :  REM A INPUT,B OUTPUT,C-LOW INPUT,C-HI OUTPUT
90      GOSUB 2010
100     GOSUB 2030
110     PRINT #"                    "
120     JUMPER=XBY(65508).AND.128 :  IF JUMPER=0 THEN 2140
130     FOR P=0 TO 5
140     XBY(65509)=2**P
150     SW(P)=XBY(65510).AND.15
160     NEXT P
170     SW2=1000*SW(3)+100*SW(2)+10*SW(1)+SW(0) :  REM S/MED FOR KILDEN
180     SW1=10*SW(5)+SW(4)
185     ORD=SW1*.1 :  REM ORDINERET 24H ROD (1 DECIMAL)
190     IF SW2=0 THEN 1630
200     XBY(65510)=0 :  REM DIODES OFF
210     F=0 : SB=0
220     N=0
230     GOSUB 640
240     IF M(N)>100 THEN 130
250     IF SW1>40 THEN 300
260     GOSUB 2010
270     GOSUB 2030
280     PRINT #"                    "
290     GOTO 340
300     GOSUB 2010
310     GOSUB 2050
320     PRINT #"                    "
330     GOTO 130
340     N=N+1
350     IF N<3 THEN 230
360     XBY(65509)=128 :  REM PB7=LYDGIVER ON
370     FOR T=0 TO 10 :  NEXT T
380     XBY(65509)=0 :  REM PB7=LYDGIVER OFF
390     XBY(65510)=16 :  REM PC4 HI GREEN DIODE ON.
400     FOR T=0 TO 200 :  NEXT T
410     FOR N=0 TO 4
420     GOSUB 640
430     G(N)=M(N)
440     NEXT N
450     XBY(65509)=128
460     FOR T=0 TO 10 :  NEXT T
470     XBY(65509)=0
480     XBY(65510)=0 :  REM  DIODES OFF
490     FOR T=0 TO 200 :  NEXT T
500     FOR N=0 TO 4
510     GOSUB 640
520     S(N)=M(N)
530     NEXT N
540     XBY(65509)=128
550     FOR T=0 TO 10 :  NEXT T
```

```
560   XBY(65509)=0
570   XBY(65510)=64 :  REM PC6 HI RED DIODE ON.
580    FOR T=0 TO 200 :  NEXT T
590    FOR N=0 TO 4
600    GOSUB 640
610   R(N)=M(N)
620    NEXT N
630    GOTO 830
640    DO
650   I=XBY(65508) : C=I.AND.112
660    UNTIL C=112 :  REM I.E.PA6,PA5 OG PA4 HI.
670    DO
680   I=XBY(65508) : C=I.AND.112
690    UNTIL C=48 :  REM  I.E. PA6 LO I.E. HUNDREDS SELECTED.
700   H=I.AND.15
710    DO
720   I=XBY(65508) : C=I.AND.112
730    UNTIL C=96 :  REM I.E. PA4 LO I.E. UNITS SELECTED.
740   U=I.AND.15
750    DO
760   I=XBY(65508) : C=I.AND.112
770    UNTIL C=80 :  REM I.E. PA5 L I.E. TENS SELECTED.
780   T=I.AND.15
790   FT=1
800    IF H=10 THEN H=0 : FT=-1
810   M(N)=FT*(100*H+10*T+U)
820    RETURN
830   XBY(65509)=128 : XBY(65510)=0
840    FOR T=0 TO 100 :  NEXT T
850   XBY(65509)=0
860   GMIN=1000 : SMIN=1000 : RMIN=1000
870   GMAX=0 : SMAX=0 : RMAX=0
880   GS=0 : SS=0 : RS=0
890    FOR N=0 TO 4
900   GS=GS+G(N) : SS=SS+S(N) : RS=RS+R(N)
910    IF G(N)<GMIN THEN GMIN=G(N)
920    IF G(N)>GMAX THEN GMAX=G(N)
930    IF S(N)<SMIN THEN SMIN=S(N)
940    IF S(N)>SMAX THEN SMAX=S(N)
950    IF R(N)<RMIN THEN RMIN=R(N)
960    IF R(N)>RMAX THEN RMAX=R(N)
970    NEXT N
980    IF GMAX-GMIN>40 THEN F=1
990    IF SMAX-SMIN>10 THEN F=1
1000   IF RMAX-RMIN>40 THEN F=1
1010  RG=.1*INT((GS-SS)/4.5)
1020  RR=.1*INT((RS-SS)/4.5)
1030   IF RG<5 THEN F=1
1050   IF F=1 THEN 1180
1100  GI=LOG(RG)-1.54 :  REM ln(RG)-intercept
1110  SL=GI/RR :  REM slope
1120  KR=RR+17.5*(1-SL/.0427) :  REM KORR. RED REFL.
1130  KGI=.0427*KR :  REM KORR GR REFL
1150   IF KR=0 THEN F=1
1160   IF KR<0 THEN F=1
1170   IF F=0 THEN 1350
```

```
1180  GOSUB 2010
1190  GOSUB 2070
1200  GOSUB 2090
1210  FOR T=0 TO 600 :  NEXT T
1220  GOTO 90
1350 PMT=100*(70-KR)/70 :  IF PMT<0 THEN PMT=0
1360 REDN=100*(.0427-SL)/.0277 :  IF REDN<0 THEN REDN=0
1365  IF PMT>60 THEN SB=1
1370 PMT=INT(PMT)
1380 REDN=INT(REDN)
1390  PRINT #CHR(27),"I",CHR(17),CHR(22),
1400  PRINT #" PIGMENTATION ",PMT,"%"
1405  IF SB=1 THEN  PRINT #" REDNESS UNRELIABLE " :  GOTO 1420
1410  PRINT #" REDNESS       ",REDN,"%"
1420  FOR T=0 TO 2000 :  NEXT T
1430 PP=.483+.0829*PMT :  REM PIGM.BESK.FAKTOR
1440 PP=.1*INT(10*PP)
1450  PRINT #CHR(27),"I",CHR(17),CHR(22),
1460  PRINT #" PIGMENT PROTECTION"
1465  IF PP>.483 THEN 1470 :  REM IF PMT=0
1467  PRINT #"     UNRELIABLE     "
1468  FOR T=0 TO 2000 :  NEXT T
1469  GOTO 90
1470  PRINT #" FACTOR ",PP
1480  FOR T=0 TO 2000 :  NEXT
1485 ARD=16.97-491.5*SL :  REM  ACTUELL REDNESS
1486  IF PMT<13 THEN PMT=13 :  REM TAALES ALTID
1488  IF SW2>0.AND.SW2<16 THEN  GOTO 3000
1490  IF PMT>60 THEN 1500
1491  REM  IF REDN>29.6 THEN 1510  erstattet af advarsel
1492  IF REDN<29.6 THEN 1500
1493  PRINT #CHR(27),"I",CHR(17),CHR(22),
1494  FOR T=0 TO 4
1495  PRINT #" CHECK SKIN REDNESS "
1496  FOR P=0 TO 200 :  NEXT P
1497  PRINT #"                   "
1498  FOR P=0 TO 50 :  NEXT P
1499  NEXT T
1500 TT=(-0.9+.689*ORD+.0829*PMT)*SW2
1502  IF SW15=1 THEN TT=-2300+2200*ORD+205*PMT : SW15=0
1503  REM -2000 PGA REGIONSFORSKELLE.
1506  GOTO 1520
1510  REM  TT=.689*(ORD-ARD)*SW2
1520  PRINT #CHR(27),"I",CHR(17),CHR(22),
1530 TT=INT(TT) :  IF TT<0 THEN TT=0
1531  IF LSW=0 THEN 1540
1532  PRINT #"   TREATMENT DOSE "
1533  IF TT<1000 THEN  PRINT #"    ",TT,"MJ/SQCM" :  GOTO 1537
1534 TT=INT(TT/100) : UVD=TT/10
1536  PRINT #"  ",UVD,"J/SQCM"
1537  FOR T=0 TO 2000 :  NEXT T
1538 LSW=0
1539  GOTO 120
1540 H=INT(TT/3600)
1550 M=INT((TT-3600*H)/60)
1560 S=TT-M*60-H*3600
```

```
1570  PRINT #"   TREATMENT TIME "
1580  IF H=0 THEN 1600
1590  PRINT #"  ",H,"HOUR",M,"MIN"  :  GOTO 1622
1600  IF M=0 THEN 1620
1610  PRINT #"  ",M,"MIN ",S,"SEC    " :  GOTO 1622
1620  PRINT #"      ",S,"SEC     " :  GOTO 1622
1622  FOR T=0 TO 2000 :  NEXT T
1624  GOTO 120
1630  PRINT #CHR(27),"I",CHR(17),CHR(22),
1640  PRINT #"*CALIBRATE*   PLACE"
1650  PRINT #"DETECTOR ON STANDARD"
1660 XBY(65509)=1
1670 SW=XBY(65510).AND.15 :  IF SW>0 THEN 10
1680 XBY(65509)=2
1690 SW=XBY(65510).AND.15 :  IF SW>0 THEN 10
1700 XBY(65509)=4
1710 SW=XBY(65510).AND.15 :  IF SW>0 THEN 10
1720 XBY(65509)=8
1730 SW=XBY(65510).AND.15 :  IF SW>0 THEN 10
1740  FOR T=0 TO 1000 :  NEXT T
1750 XBY(65510)=32
1760  FOR T=0 TO 200 :  NEXT T
1770  GOSUB 640
1780 S=M(N)
1790  IF S>40 THEN 1630
1800 XBY(65510)=48
1810  FOR T=0 TO 200 :  NEXT T
1820  GOSUB 640
1830 G=M(N)
1840 GP=.1*INT((G-S)/.9)
1850 XBY(65509)=128
1860  FOR T=0 TO 5 :  NEXT T
1870 XBY(65509)=0
1880  PRINT #CHR(27),"I",CHR(17),CHR(22),
1890  PRINT #GP,"%", TAB (9),"GREEN      "
1900 XBY(65510)=96
1910  FOR T=0 TO 200 :  NEXT T
1920  GOSUB 640
1930 R=M(N)
1940 XBY(65510)=32
1950 RP=.1*INT((R-S)/.9)
1960 XBY(65509)=128
1970  FOR T=0 TO 15 :  NEXT T
1980 XBY(65509)=0
1990  PRINT #RP,"%", TAB (9),"RED        "
2000  GOTO 1660
2010  PRINT #CHR(27),"I",CHR(17),CHR(22),
2020  RETURN
2030  PRINT #"   *** READY ***   "
2040  RETURN
2050  PRINT #" CHECK DOSE SETTING"
2060  RETURN
2070  PRINT #"ERROR  ERROR  ERROR"
2080  RETURN
2090  PRINT #" REPEAT MEASUREMENT"
2100  RETURN
```

```
2110  REM ***
2120  REM ***
2130  REM ***
2140  REM TESTPG FOR HUDREFLEKTANSMETER.TEST.BAS
2150  REM *** INITIALISERING
2160  REM 100% refl=900 mV
2170  REM FFE7H=65511=CONTROLREG.
2180  REM FFE6H=65510= C-PORTE
2190  REM FFE5H=65509= B-PORTE.
2200  REM FFE4H=65508= A-PORTE.
2210  BAUD 2400 :  REM BAUDRATE TIL DISPLAY
2220 XBY(65511)=145 :  REM A INPUT,B OUTPUT,C-LOW INPUT,C-HI OUTPUT
2230  PRINT #CHR(27),"I",CHR(17),CHR(22),
2240  REM *** INIT SLUT
2250  PRINT #"TESTER LYDGIVER"
2260  FOR N=0 TO 1
2270 XBY(65509)=128
2280  FOR T=0 TO 50 :  NEXT T
2290 XBY(65509)=0
2300  FOR T=0 TO 50 :  NEXT T
2310  NEXT N
2320  PRINT #" TESTER OMSKIFTERE"
2330  DIM SW(6)
2340  FOR P=0 TO 5
2350 XBY(65509)=2**P
2360 SW(P)=XBY(65510).AND.15
2370  NEXT P
2380  FOR P=5 TO 4 STEP -1
2390  PRINT #SW(P),
2400  NEXT P
2410  PRINT #"   ",
2420  FOR P=3 TO 0 STEP -1
2430  PRINT #SW(P),
2440  NEXT P
2450  PRINT #
2460 SW2=1000*SW(3)+100*SW(2)+10*SW(1)+SW(0)
2470 SW1=10*SW(5)+SW(4)
2480  IF SW2=0 THEN 2500
2490  GOTO 2340
2500  PRINT #CHR(27),"I",CHR(17),CHR(22),
2510  PRINT #"  A/D-CONV.UDG. mV"
2520  GOSUB 2750
2530  PRINT #"   ",M, TAB (10),"          "
2540  PRINT #""
2550 XBY(65509)=1 : SW(0)=XBY(65510).AND.15
2560  IF SW(0)=1 THEN 2600
2570  IF SW(0)=2 THEN 2670
2580  GOTO 2520
2590  GOTO 2520
2600 XBY(65510)=16 :  REM PC4 HI GREEN DIODE ON.
2610  FOR T=0 TO 200 :  NEXT T
2620  GOSUB 2750
2630 XBY(65510)=0 :  REM  DIODES OFF
2640  PRINT #"   ",M, TAB (10),"GREEN    "
2650  PRINT #""
2660  GOTO 2550
```

```
2670  XBY(65510)=64 :  REM PC6 HI RED DIODE ON
2680   FOR T=0 TO 200 :  NEXT T
2690   GOSUB 2750
2700  XBY(65510)=0 :  REM   DIODES OFF
2710   PRINT #"  ",M, TAB (10),"RED      "
2720   PRINT #""
2730   GOTO 2550
2740   REM ***AFLAESNING AD A/D-CONVERTER
2750   DO
2760  I=XBY(65508) : C=I.AND.112
2770   UNTIL C=112 :  REM I.E.PA6,PA5 OG PA4 HI.
2780   DO
2790  I=XBY(65508) : C=I.AND.112
2800   UNTIL C=48 :  REM  I.E. PA6 LO I.E. HUNDREDS SELECTED.
2810  H=I.AND.15
2820   DO
2830  I=XBY(65508) : C=I.AND.112
2840   UNTIL C=96 :  REM I.E. PA4 LO I.E. UNITS SELECTED.
2850  U=I.AND.15
2860   DO
2870  I=XBY(65508) : C=I.AND.112
2880   UNTIL C=80 :  REM I.E. PA5 L I.E. TENS SELECTED.
2890  T=I.AND.15
2900  FT=1
2910   IF H=10 THEN H=0 : FT=-1
2920  M=FT*(100*H+10*T+U)
2930   RETURN
2940   REM *** AFLAESNING SLUT
3000  LSW=1
3010   IF SW2=1 THEN SW2=334 :  REM INCL CORR 1.85
3020   IF SW2=2 THEN  GOTO 3200
3030   IF SW2=3 THEN  GOTO 3200
3040   IF SW2=4 THEN  GOTO 3200
3050   IF SW2=5 THEN  GOTO 3200
3060   IF SW2=6 THEN  GOTO 3200
3070   IF SW2=7 THEN GOTO 3200
3080   IF SW2=8 THEN SW2=52880
3090   IF SW2=9 THEN SW2=21081
3100   IF SW2=10 THEN SW2=52880
3110   IF SW2=11 THEN GOTO 3200
3120   IF SW2=12 THEN SW2=82
3130   IF SW2=13 THEN GOTO 3200
3140   IF SW2=14 THEN goto 120
3150   IF SW2=15 THEN SW15=1
3160   GOTO 1490
3200   GOSUB 2010
3210   GOSUB 2070
3220   FOR T=0 TO 2000 :  NEXT T
3230   GOTO 90
```

In case the programme is adapted to control the microprocessor of the apparatus according to the present invention in accordance with the above described alternative calculations relating to the comparison of the UV dose in B-MED and the degree of pigmentation, the lines 1500 and 1510 of the programme are amended into:

```
1500      TT=(-0.206+0.689xORD+0.0829xPIG%) and
1510      TT=.689x(ORD-ARD).
```

The apparatus according to the present invention should be operated in accordance with the below measuring guidelines:

The undressed patient should acclimate before the measurement. This is to evaporate sweat from the skin and cool. Measurements is performed on normal or relatively normal skin avoiding discoloration from treatment, freckles, hairy areas even after shaving, flushing zones, and skin irritated from rubbing by the person himself or from the back of a chair. If fullbody treatment is performed the best place to measure is on the back above a horizontal line through the lower part of the scapulae, and on the upper part of the abdomen and the breast. Measurements on the extremities will only be reproducible if the patient is placed horizontally and relaxing. Redness will change with level and activity.

The detector is held perpendicular to the surface of the skin gently touching the skin in order to eliminate light from entering the detector from the environment.

Light sources used for the treatment of skin diseases may have very different biological activity. And since the limiting factor for the treatment dose is redness of the skin, the use of a basic MED has been chosen as the basic dose. The basic MED being calculated from the erythema action spectrum CIE (McKinlay & Diffey) and the MED dose of 31,2 mJ/cm2 at 296 nm (Parrish).

The correct number of seconds to reach that dose, i.e. 1B-MED, is entered into the microprocessor by means of the the thumb wheel 20 at the right-hand side of the display 16.

By means of the thumb wheel 16 at the left-hand side of the display 20, the "24h erythema level" is input. This level has to be decided by the person operating the apparatus.

0.0 Corresponds to the highest dose which can be given before redness will appear.

0.5 Corresponds to (+) redness, weak spotted redness without sharp borders to the untreated surroundings.

1.0 Weak redness with a clear demarcation to the surroundings. Often named +.

2.0 Corresponds to redness ++ with clear redness and a weak edema to be felt.

3.0 Corresponds to +++ redness. There is heavy redness with edema above the surroundings.

Therefore, the following schedule is recommended for the treatment of psoriasis:

1. Week of treatment	setting 1.0
2. Week of treatment	3.0
3. week of treatment	6.0
4. Week of treatment	9.0

A constant erythema level setting may be used for atopic dermatitis mycosis fungiodes, pruritus etc.

Pigmentation

The scale has been chosen so that people with a very wide range of pigmentation covering all races are represented in the scale. Pigmentation is given on a scale from 0% to 100%. 0% pigmentation represents the degree of pigmentation of previously unirradiated buttocks of an extremely white person. 100% pigmentation represents the degree of pigmentation of previously unirradiated buttocks of a very black person.

In the first few days after intensive UV irradiation redness corresponding to ++ and +++ etc. will result in a lower measure of pigmentation than the measurement preceding irradiation. This phenomenon is a result of edema following heavy erythema and is caused by erythema itself.

Erythema

The scale is chosen so that people with zero blood flow and dark blue red naevus flammeus can be fitted into the scale.

0% redness has been chosen as the redness of the skin on the antebrachium of persons who had their arm emptied for blood and the blood supply stopped by a cuff on the upper arm.

100% has been chosen so that even very blue-red naevus flammeus of the face may be included.

0-30% corresponds to what is found under normal conditions in connection with people acclimated to room temperature.

The relations between the clinical degree of redness and the average % of UV irradiated people or individuals are listed in Table 1.

The pigment protection factor indicates how much higher UV dose an individual can take before obtaining + in redness compared to a person reacting with + redness.

After exposure to 1 B-MED from a Philips TL 12 equipped radiation source. All background measurements are to be performed on previously unexposed buttocks.

Treatment time shown on the display 16 is the time used for full body irradiation. Therefore, the irradiation dose matches the most sensitive larger areas of the body. It should be noted that the treatment time depends on the radiation source and the setting of the thumb wheel switch 20.

When the thumb wheel switch 20 at the right-hand side of the display 16 is adjusted to 0000 (no radiation) the apparatus automatically jumps into calibration mode.

Keeping the detector close to the tile which is delivered together with the apparatus a reflection % for the red and green light is shown on the display. This reflection should be within the limits written on the tile.

Before calibration, the apparatus must be in temperature equilibrium with the room in which the apparatus is to be used.

The calibration values is traceable to standard ISO 2469. Using this standard will display 100% both for red and green reflection.

The detector is constructed to demand a minimum of cleaning. Only a plastic ring is in contact with the skin. This may be cleaned by an alcoholic solution.

In Fig. 14 a diagram is shown illustrating the basic realization that a linear relationship exists between light- or laser-induced skin changes to individuals and the degree of skin pigmentation of the same individuals. The diagram shown in Fig. 14 was based on the below test.

Thirteen individuals with a varying degree of epidermal skin pigmentation, objectified by skin reflectance, were on the inside of the upper arm treated with a total of six hexagonal areas by an argon laser (AL, 488 nm) and a copper vapor laser (CVL, 578nm). The lasers were connected to a Hexascan device, and physical parameters were identical for the two laser types, except for the wavelengths. Beam diameter was 1 mm, pulse duration 200 msec, intensities 0.7, 1.0, and 1.3 W/spot, resulting in the following spot doses 17.8, 25.5, and 33.1 J/cm².

A correlation was demonstrated between pre-treatment skin pigmentation and the clinical effects obtained immediately after and 6 months after the laser treatment. Assessment of the chronic response was based on distinction between pigmentary changes and scarring.

The CVL induced a significantly higher degree of acute results at the 0.7 and 1.0 W/spot treatment level as compared with the AL. For the clinical response 6 months after the laser treatment it turned out that the AL at the 1.0 and 1.3 W/spot induced a significantly higher degree of hyperpigmentation and scarring as compared with the CVL.

An inverse relation was found between the degree of pre-treatment pigmentation and the threshold intensities required to induce wound formation, scar formation and postinflammatory hyperpigmentation, respectively.

Detailed measuring results obtained by the above test are illustrated in the diagrams 15A-15L.

In Fig. 16, a diagram is shown, illustrating the relation of using the degree of skin pigmentation as a predictor of minimal phototoxic dose to be given to the same individual. The diagram represents the result of the following test or experiment.

Fourteen individuals with skin type (II) (11) and skin type III (3) participated in the test. The sensitivity to irradiation with Philips TL12 tubes was determined without medication on previous unexposed buttocks (MED). The sensitivity to irradiation with Philips TL09 tubes was determined 1 h after oral administration of (0.44-0.63 mg/kg) 8-MOP in a similar way (MPD). The pigmentation of the test areas before irradiation was quantitated with an apparatus according to the present invention,

the erythema reaction was assessed clinically using a (+)-+++ scale 24 h after TL12, and 72h after TL09 exposure.

The pigmentation % of the unexposed test areas vs. the energy needed to elicit MED or MPD was plotted in scattergrams. There was a positive relation between pigmentation and the dose of TL12 needed to elicit a (+) or + erythemal reaction. The lines of the (+) and + reaction had identical slopes. Similar results were observed with TL09 exposure after ingestion of 8-MOP. Spearmanns test for correlation between pigmentation and dose to erythemal reaction was significant for the + reaction after TL12 exposure, $p<0.05$. The correlation coefficient for the other parameters was non-significant ($0.4>p>0.05$).

A further experiment was made:

Seventeen volunteers were tested with Philips TL12 and TL01 tubes on previous unexposed buttocks. Biological doses ranging from 0.25 to 3.00 B-MEDs were used.

B-MED derived from the erythema action spectrum of McKinlay and Diffey and 1 MED = 312 J/m² at 296 nm (Parrish). The physical doses corresponding to 1 B-MED are 0.62 J/m² for the TL01 tube and 0.082 J/m² for the TL12 tube (TL12:TL01 ~ 1:7.5).

The redness % and pigment protection factor (PPF) were measured before and 24 h after exposure with an apparatus according to the present invention. Also the test sites were evaluated clinically after 24 h. Test sites with redness %>30 measured by the apparatus or clinical redness ((+)-+++) were included in the study. The results were given as redness % as a function of dose. Since a linear reciprocity between PPF before exposure and dose to give a specific effect is assumed to exist, the results were also given as redness % as a function of dose/PPF. As the intercept of the four lines did not differ significantly, a common intercept of 22.5 was used.

Since identical biological doses were given of the TL12 and TL01, an identical redness was expected. However,it was found that the dose ratio between TL12 and TL01 to obtain the same redness values was 1:0.55, the TL01 being 1.85 times stronger than TL12. The results are in accordance with the assumption that a linear reciprocity between PPF and the dose needed to produce a specific response exists, since it was found that 1 MED/PPF from the TL12 tube resulted in a redness of 37.1%, not significantly different from the expected 36.9%, the value corresponding to the clinical reading +.

In Fig. 17, a diagram is shown illustrating the correspondence or the difference between experimentally found UV doses and doses calculated to reach a certain redness. The diagram is based on measuring results obtained from the same 49 individuals investigated and used for the experiments or tests on basis of which the diagram shown in Fig. 6 is derived.

In Fig. 18, a diagram is shown, which diagram illustrates the adaptation of the present invention as to determining the sensitivity of an individual who has been exposed to UV treatment. The individual has after determination of the individual's ability to stand exposure to UV radiation, by employing the method and the apparatus according to the present invention, been exposed to UV treatment, i.e. been exposed to a specific UV dose. After the UV treatment, the redness of the individual is as discussed above with reference to Fig. 8 determined. The redness % is converted into a B-MED measure or difference at + redness and ++ redness, which B-MED measure represents the difference between the UV dose to which the individual has been exposed, and the UV dose which the individual may stand.

DEFINITIONS

B-MED	Basic Minimal Erythema Dose is 312 J/m^2 at 296 nm. ((24 h erythema) Parrish).
MED	Minimal Erythema Dose for an individual 24 h after exposure.
PPF	PPF x B-MED = MED The Pigment Protection Factor is the number of B-MEDs which elicit + redness in an individual 24 h after exposure.

Erythema Action Spectrum: CIE (McKinlay & Diffey).

CLAIMS

1. A method of determining an individual's ability to become tanned or to stand exposure to ultraviolet radiation without causing a skin reaction, such as skin cancer or erythema, comprising the following steps:

exposing at least part of said individual's skin surface to electromagnetic radiation of a first wavelength and of a predetermined intensity, said first wavelength being a wavelength at which erythrodermic skin reflection is high,

measuring the intensity of electromagnetic radiation reflected from said part of said individual's skin surface so as to determine a first coefficient of reflection of said skin surface part to said electromagnetic radiation of said first wavelength,

exposing said skin surface part to electromagnetic radiation of a second wavelength and of a predetermined intensity, said second wavelength being a wavelength at which erythrodermic skin reflection is low,

measuring the intensity of electromagnetic radiation reflected from said part of said individual's skin surface part so as to determine a second coefficient of reflection of said skin surface part to electromagnetic radiation of said second wavelength,

comparing said first and second coefficients of reflection with sets of coefficients of reflection representing coherent sets of coefficients of reflection of said first and second wavelengths of specific states of redness so as to determine said individual's skin surface part's state of redness, converting said first and second coefficients of reflection into a set of corrected first and second coefficients of reflection of a specific state of redness, so as to determine said individual's skin surface part's coefficients of reflection of said first and second wavelengths at a specific state of redness, and

converting said corrected first coefficient of reflection into a measure representing said individual's ability to become tanned or to stand exposure to ultraviolet radiation without causing said skin reaction.

2. A method according to Claim 1, further comprising the step of

determining said individual's skin surface part's degree of pigmentation from said corrected first and second coefficients of reflection of said first and second wavelengths at said specific state of redness.

3. A method according to Claims 1 and 2, said specific state of

redness corresponding to an average zero blood flow state.

4. A method according to any of the Claims 1-3, further comprising the steps of:

converting said second coefficient of reflection into logarithmic representation, and said sets of coefficients of reflection representing coherent sets of coefficients of reflections of said first and second wavelengths comprising coefficients of reflection of said second wavelength presented in logarithmic representation.

5. An apparatus for determining an individual's ability to become tanned or to stand exposure to ultraviolet radiation without causing a skin reaction, such as skin cancer or erythema, comprising:

a first electromagnetic source for generating electromagnetic radiation of a first wavelength and of a predetermined intensity and for directing said electromagnetic radiation of said first wavelength to a part of said individual's skin surface so as to expose said part of said individual's skin surface to said electromagnetic radiation of said first wavelength,

a second electromagnetic source for generating electromagnetic radiation of a second wavelength and of a predetermined intensity and for directing said electromagnetic radiation of said second wavelength to said part of said individual's skin surface so as to expose said part of said individual's skin surface to said electromagnetic radiation of said second wavelength,

a light-detecting means for measuring the intensity of electromagnetic radiation reflected from said part of said individual's skin surface,

a measuring means connected to said light-detecting means for measuring the intensity of electromagnetic radiation reflected from said part of said individual's skin surface so as to determine a first and a second coefficient of reflection of said skin surface part to said electromagnetic radiation of said first and second wavelength, respectively,

a comparison and converting means connected to said measuring means for comparing said first and second coefficients of reflection with sets of coefficients of reflection representing coherent sets of coefficients of reflection of said first and second wavelengths of specific states of redness so as to determine said individual's skin surface part's state of redness, for converting said first and second coefficients of reflec-

tion into a set of corrected first and second coefficients of reflection of a specific state of redness, so as to determine said individual's skin surface part's coefficients of reflection of said first and second wavelengths at a specific state of redness, and for converting said corrected first coefficient of reflection into a measure representing said individual's ability to become tanned or to stand exposure to ultraviolet radiation without causing said skin reaction.

6. An apparatus according to Claim 5, said light-detecting means comprising separate first and second light detector means for detecting electromagnetic radiation of said first and second wavelengths, respectively, reflected from said part of said individual's skin surface part.

7. An apparatus according to any of the Claims 5-6, said comparison and converting means further determining said individual's skin surface part's degree of pigmentation from said corrected first and second coefficients of reflection of said first and second wavelengths at said specific state of redness.

8. An apparatus according to any of the Claims 5-7, said specific state of redness being an average Zero blood flow state.

9. An apparatus according to any of the Claims 5-8, said comparison and converting means further converting said second coefficient of reflection into logarithmic representation, and said sets of coefficients of reflection representing coherent sets of coefficients of reflection of said first and second wavelengths comprising coefficients of reflection of said second wavelengths represented in logarithmic representation.

10. An apparatus according to any of the Claims 5-9, said first wavelength being of the order of 660 nm, and said second wavelength being of the order of 550 nm.

Fig. 1

A : White skin
B : A with redness

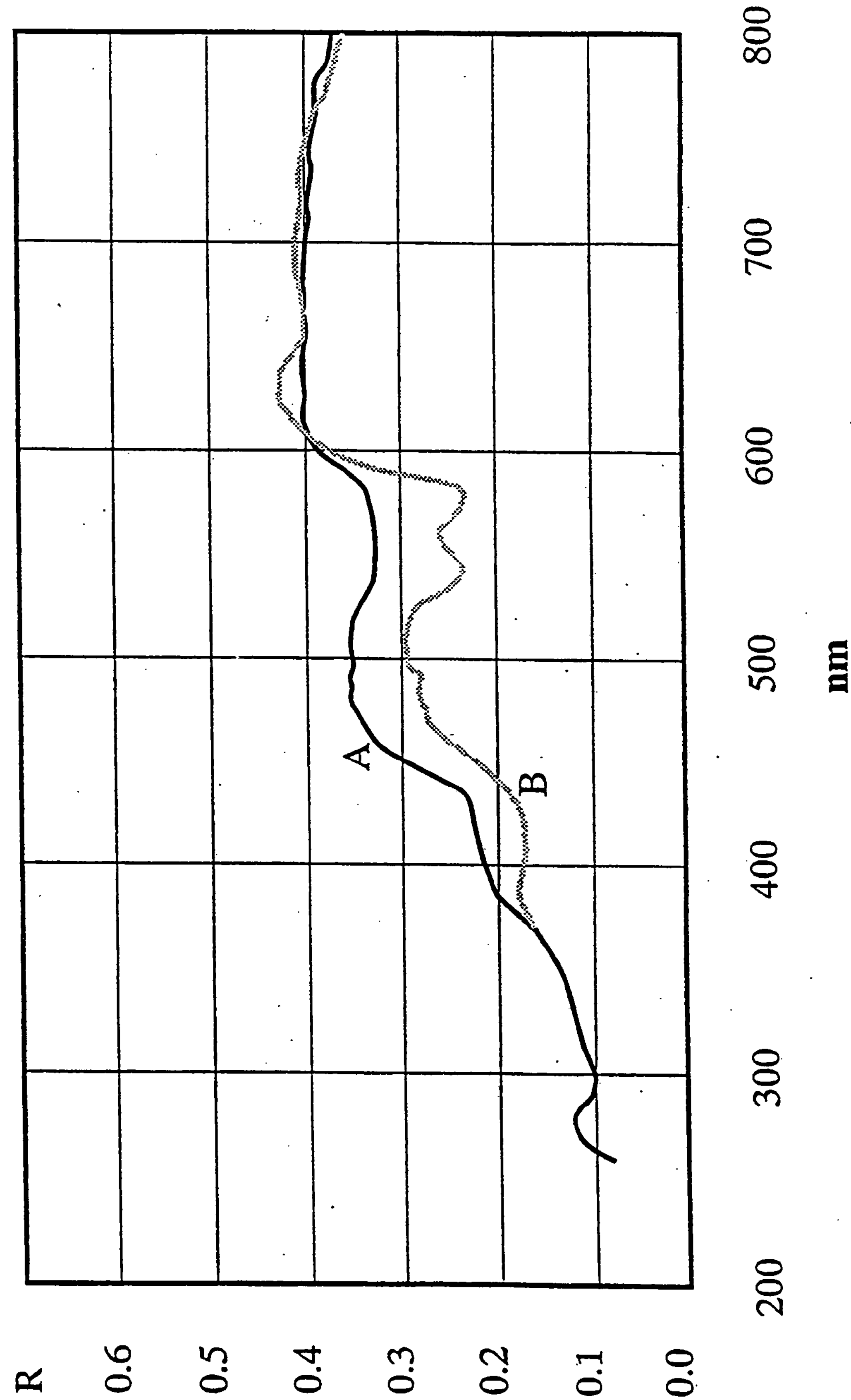
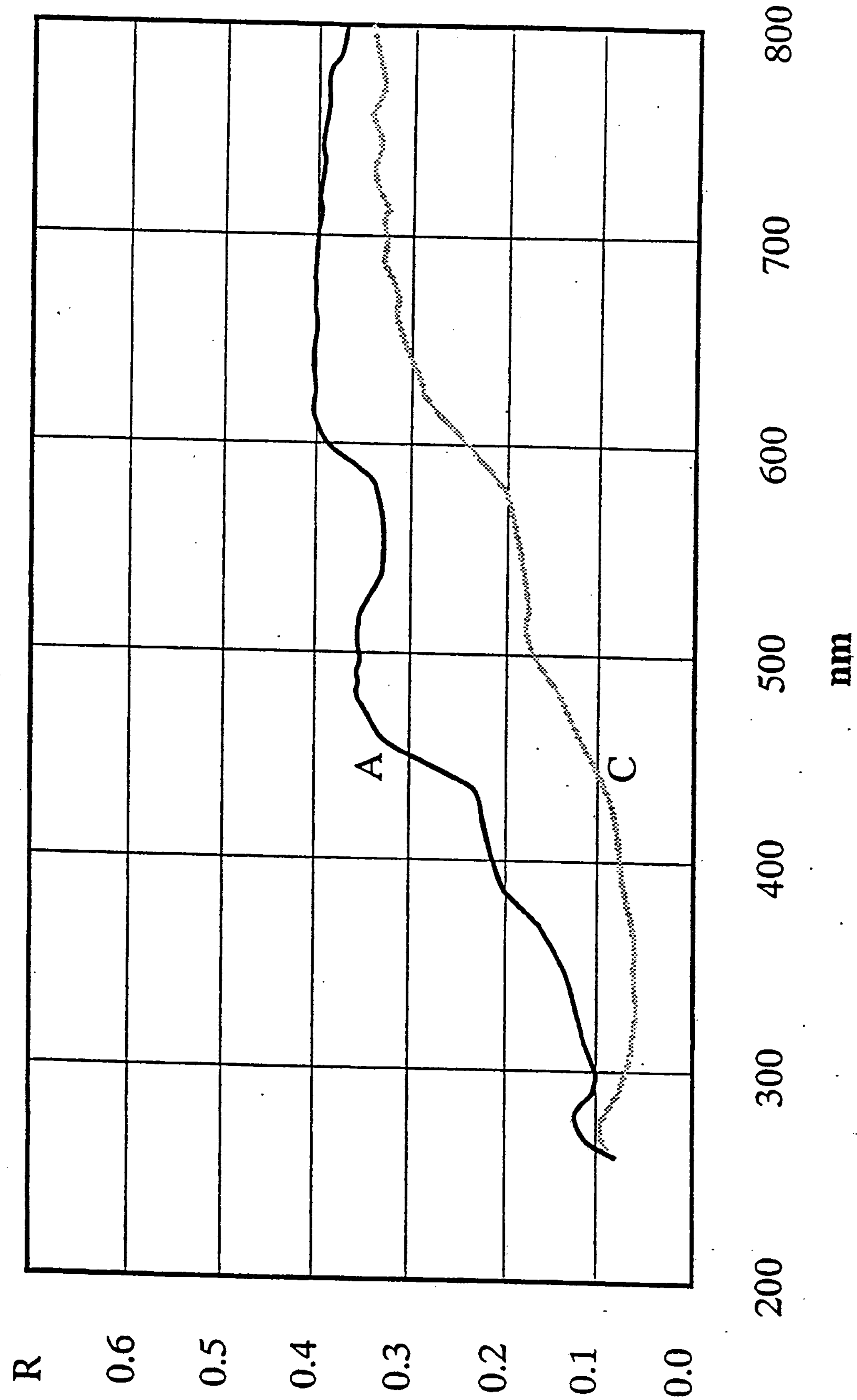


Fig. 2

A : White skin
C : Pigmented skin



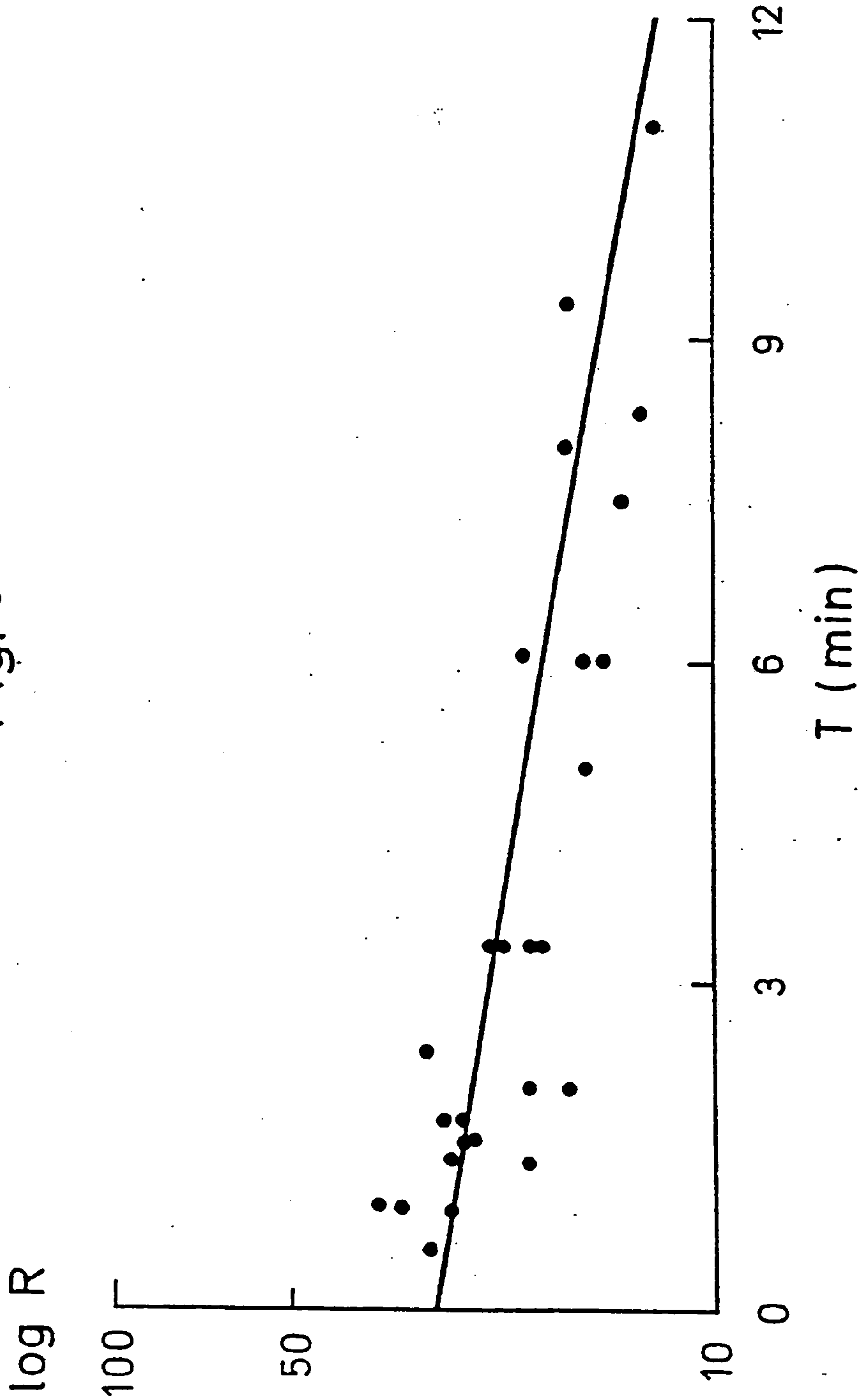
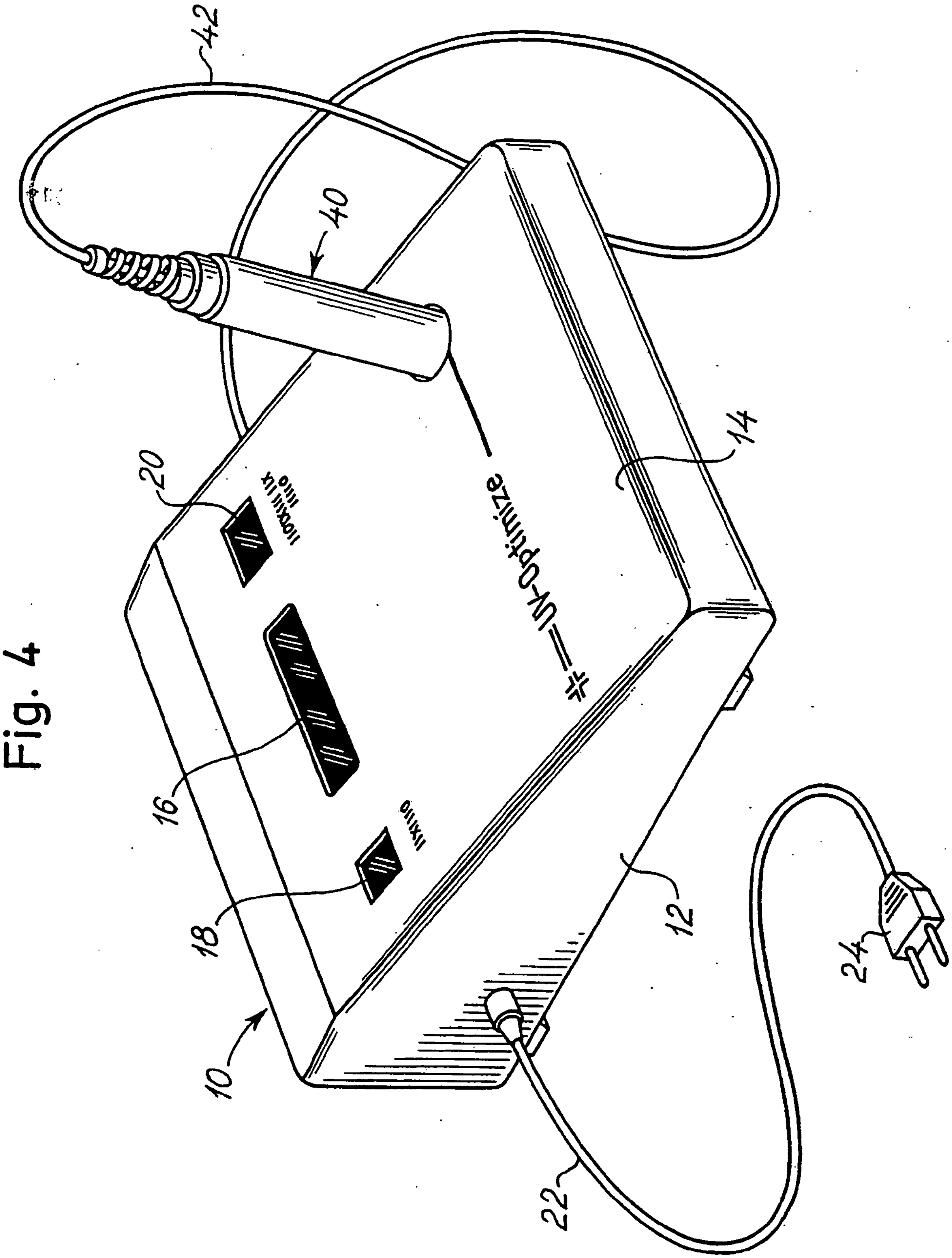


Fig. 3

Fig. 4



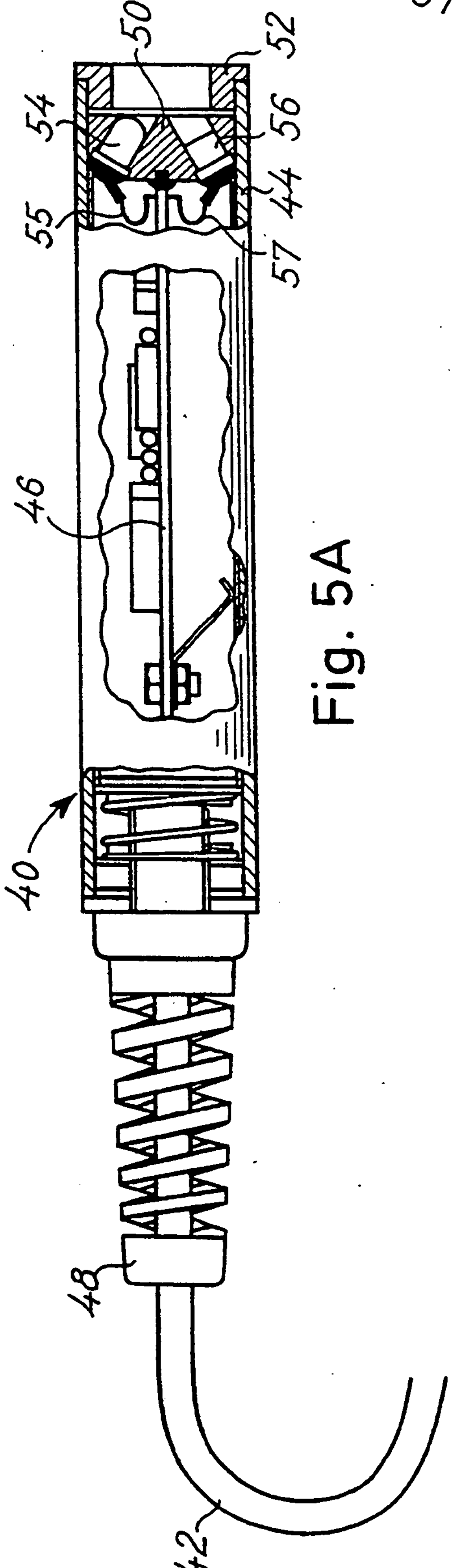


Fig. 5A

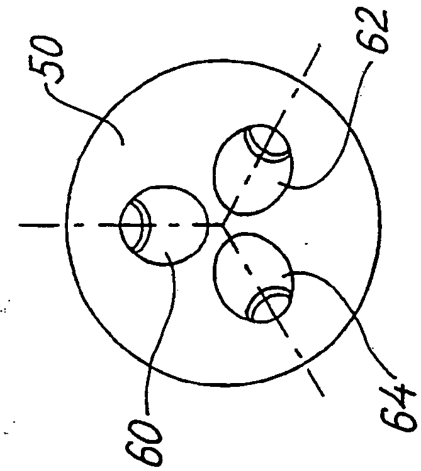


Fig. 5C

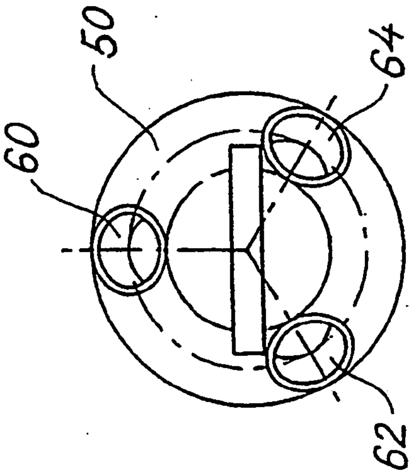
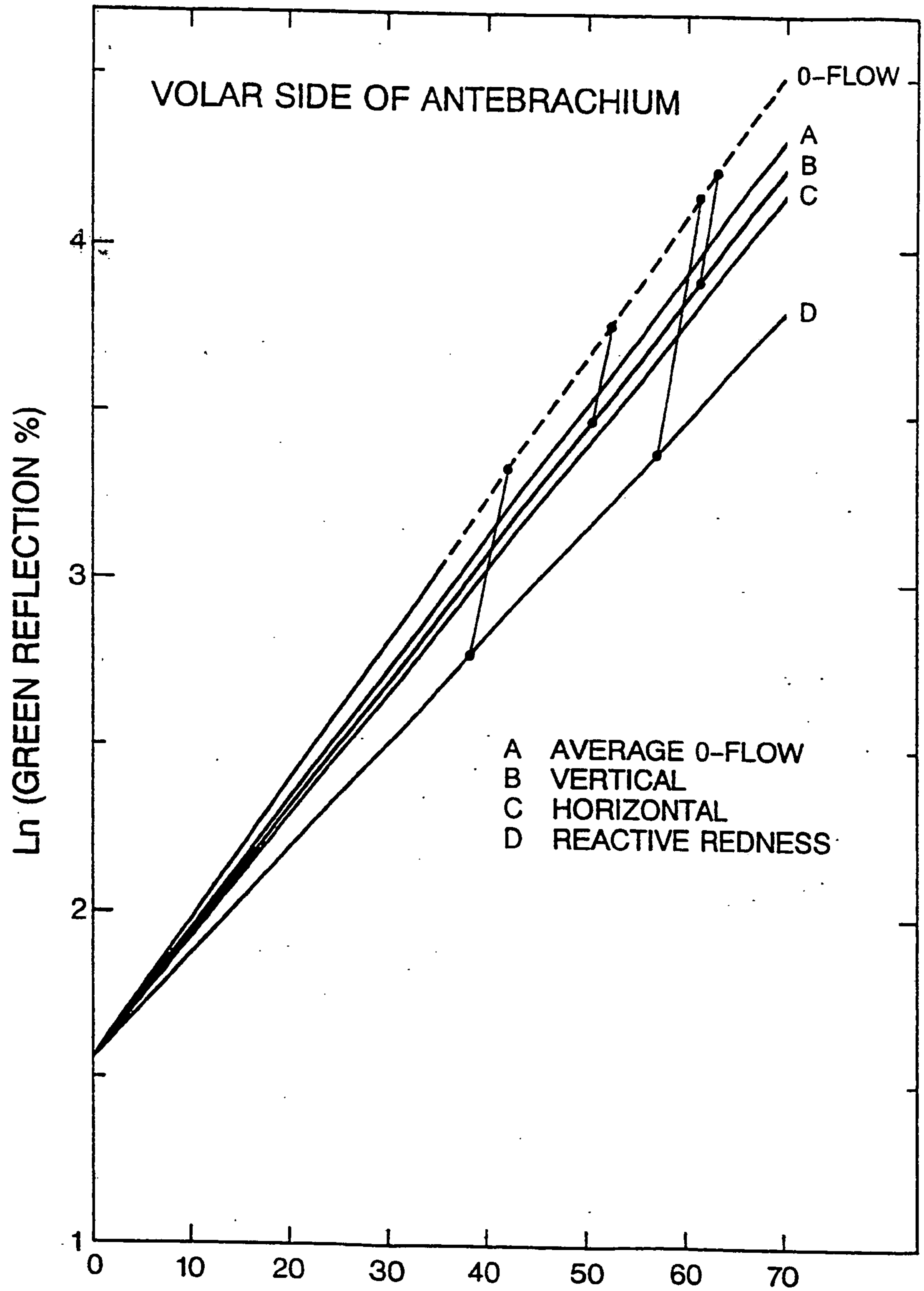
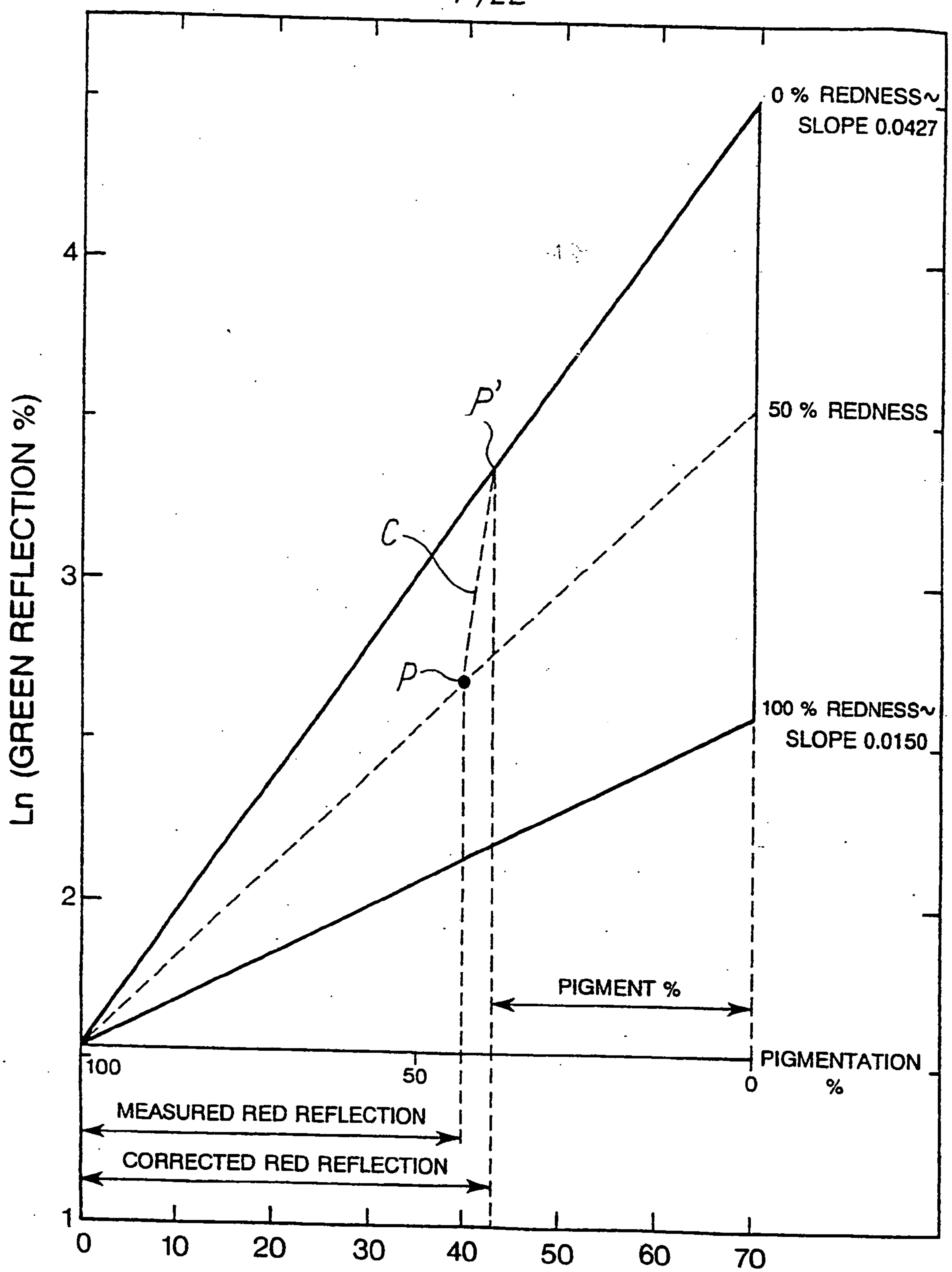


Fig. 5B



VOLAR SIDE OF ANTEBRACHIUM
0-FLOW
A
B
C
D
A AVERAGE 0-FLOW
B VERTICAL
C HORIZONTAL
D REACTIVE REDNESS
Ln (GREEN REFLECTION %)
1
2
3
4
0
10
20
30
40
50
60
70



Ln (GREEN REFLECTION %)
4
3
2
1
0 % REDNESS~
SLOPE 0.0427
50 % REDNESS
100 % REDNESS~
SLOPE 0.0150
P'
C
P
PIGMENT %
PIGMENTATION %
100
50
0
MEASURED RED REFLECTION
CORRECTED RED REFLECTION
0
10
20
30
40
50
60
70

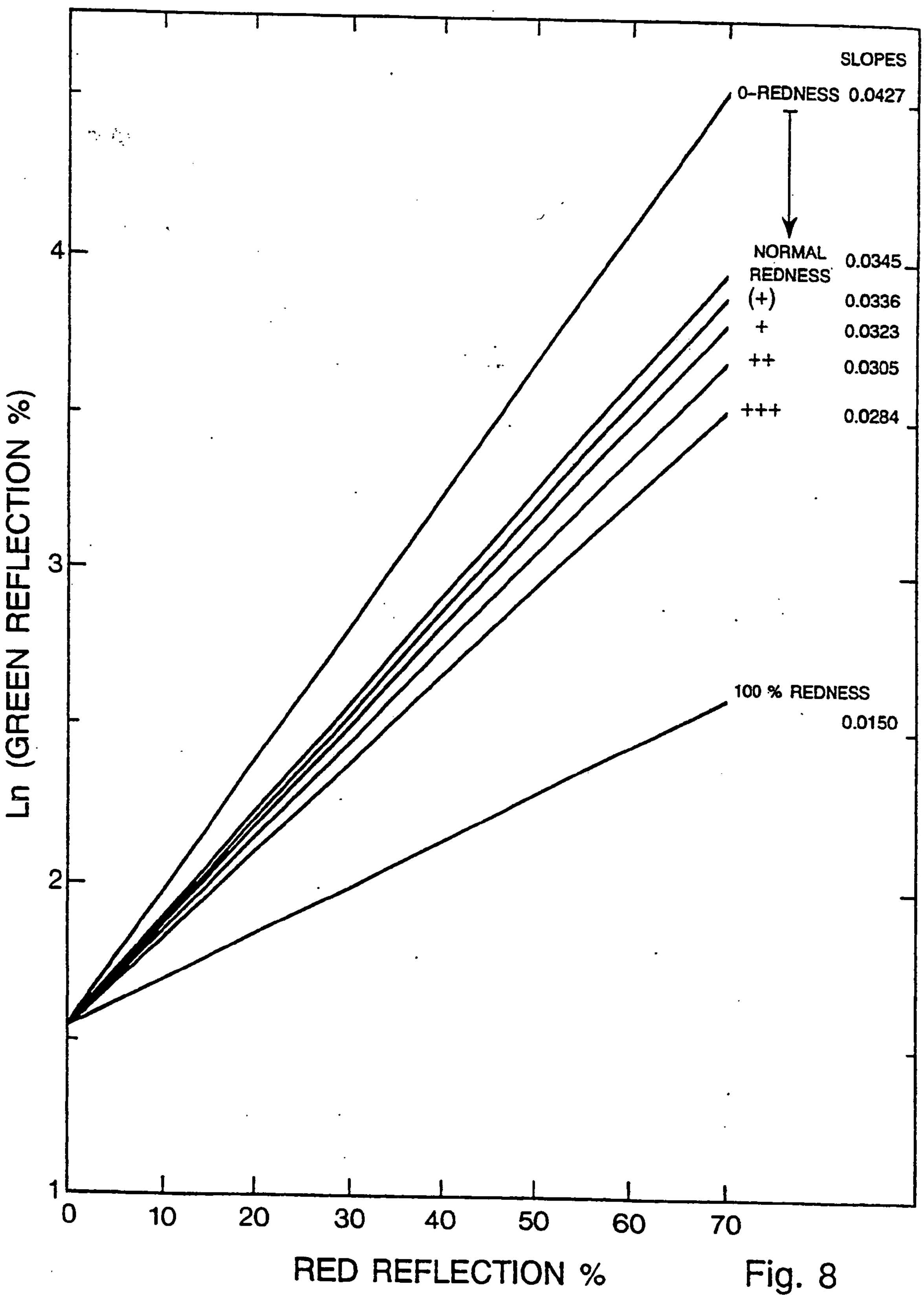

SLOPES
0-REDNESS 0.0427
NORMAL REDNESS 0.0345
(+) 0.0336
+ 0.0323
++ 0.0305
+++ 0.0284
100 % REDNESS 0.0150
Ln (GREEN REFLECTION %)
1
2
3
4
0
10
20
30
40
50
60
70
RED REFLECTION %

Fig. 8

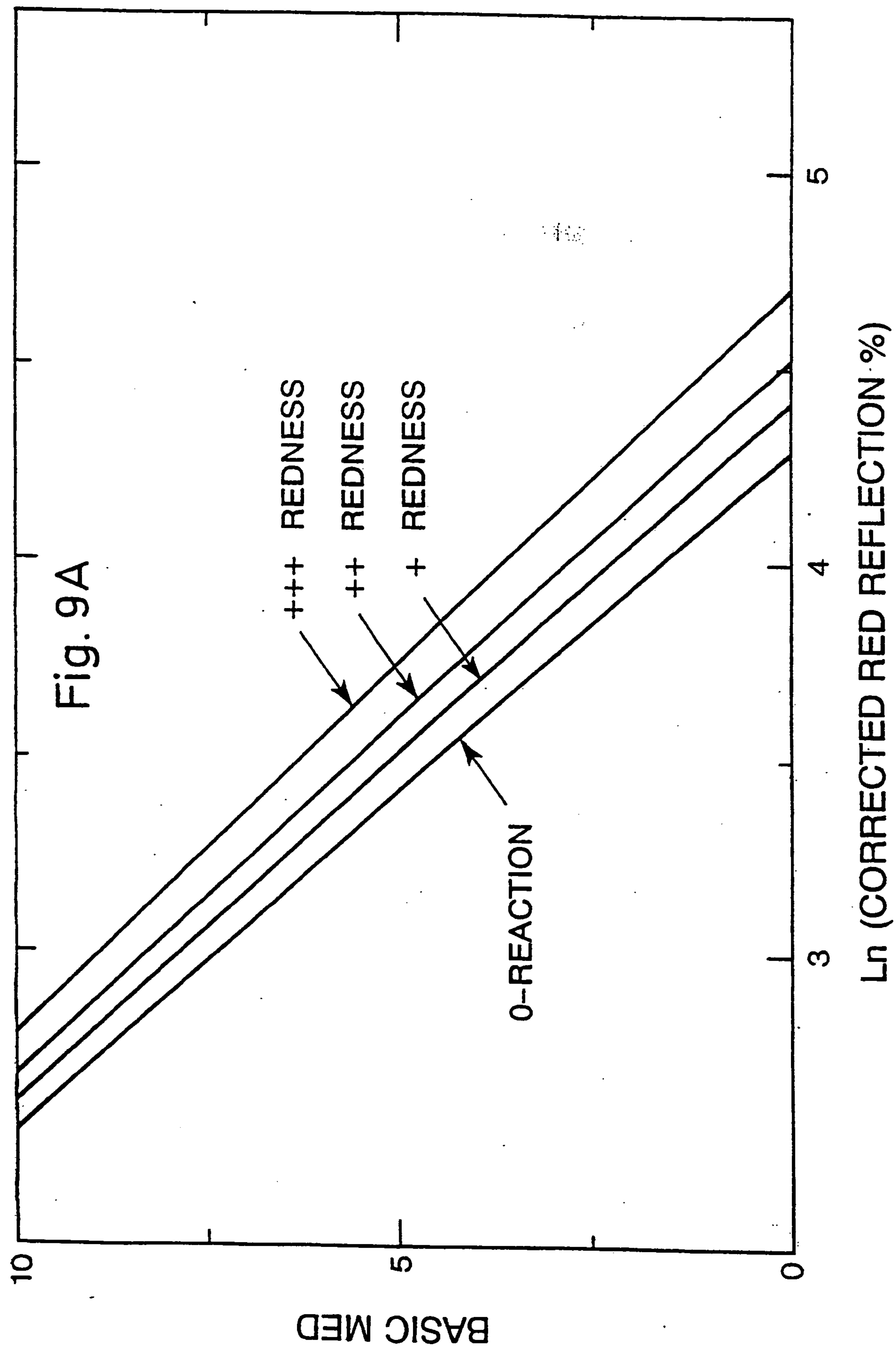

+++ REDNESS
++ REDNESS
+ REDNESS
0–REACTION
BASIC MED
Ln (CORRECTED RED REFLECTION %)
10
5
0
3
4
5

Fig. 9A

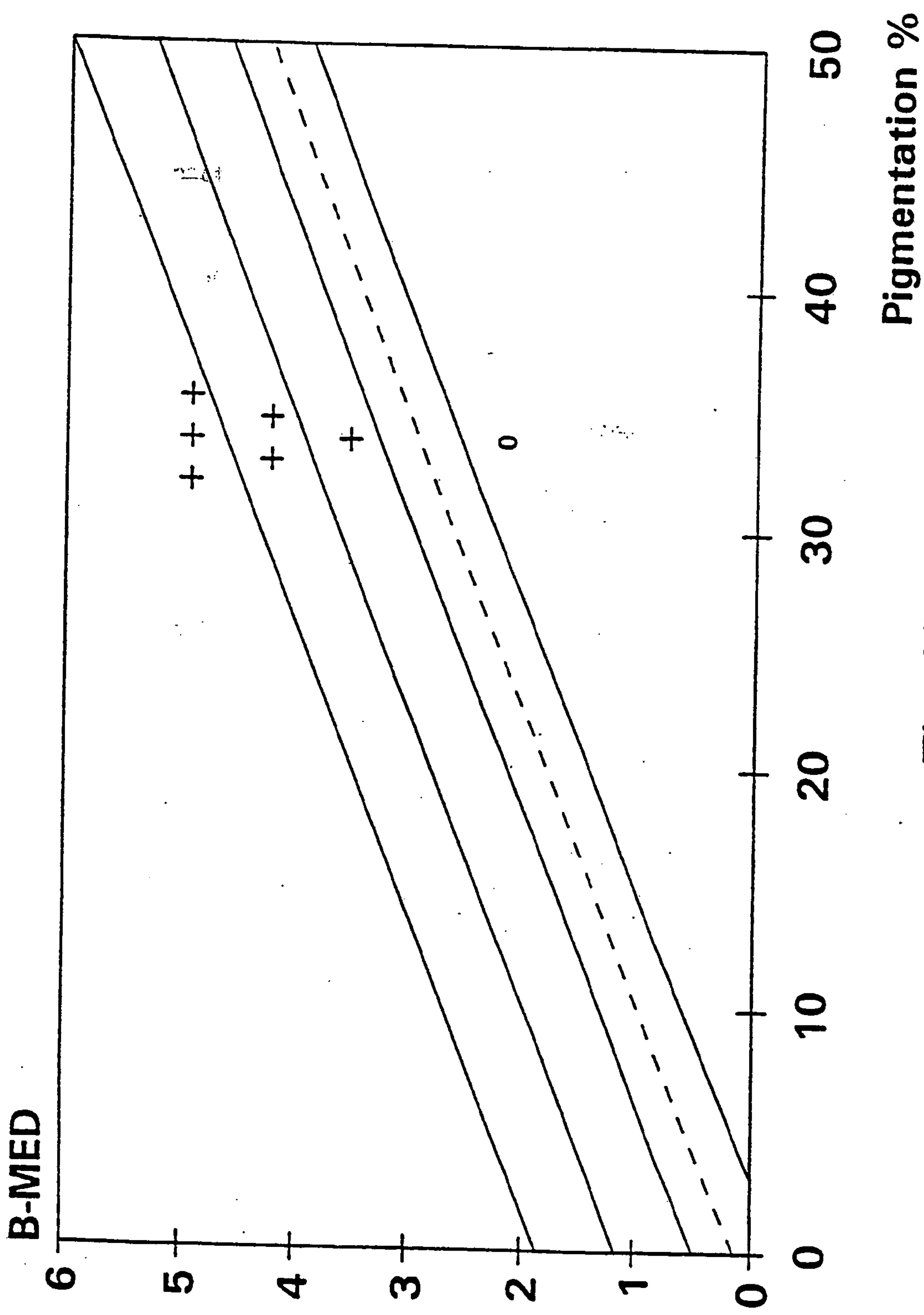


Fig. 9B

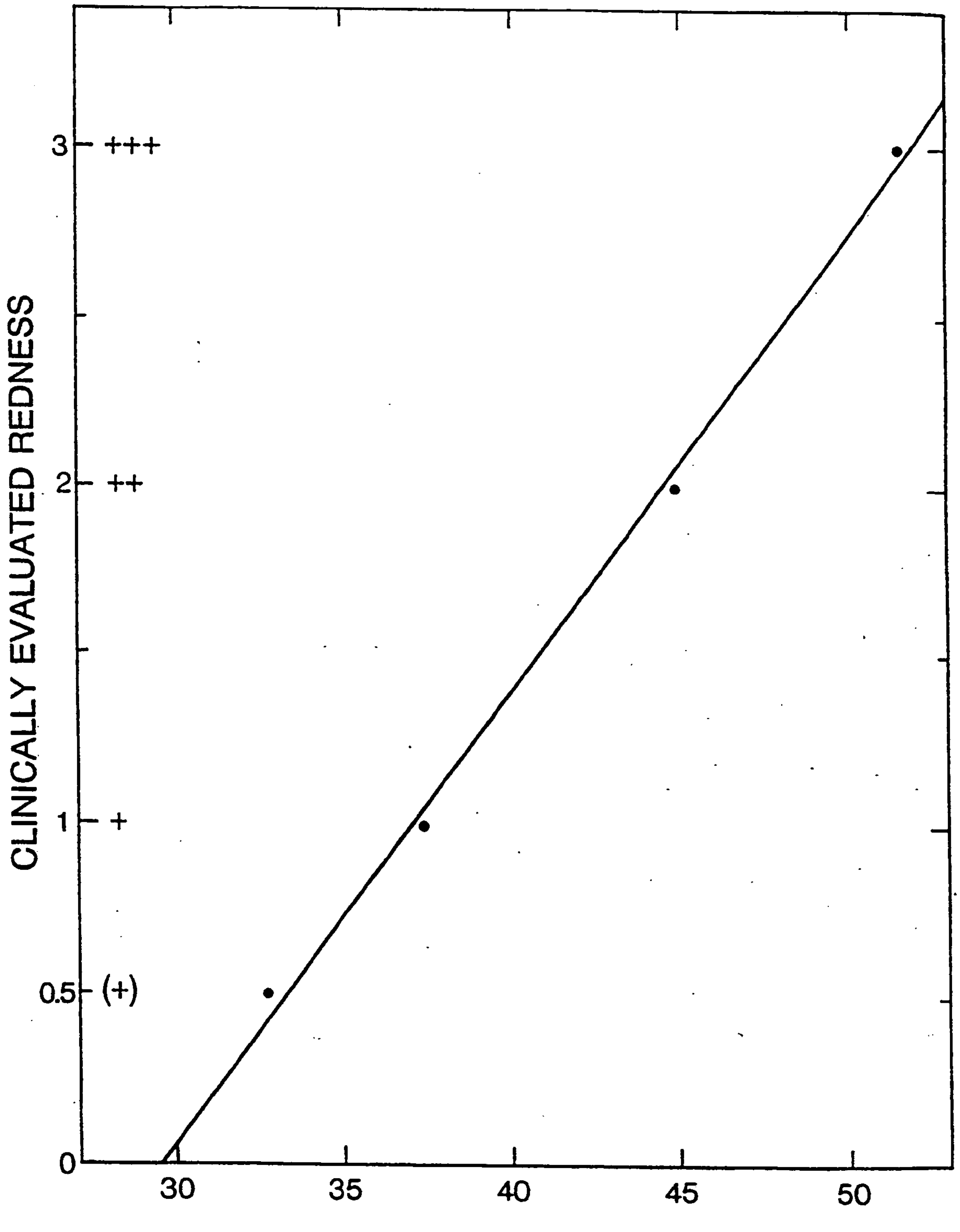


Fig. 10

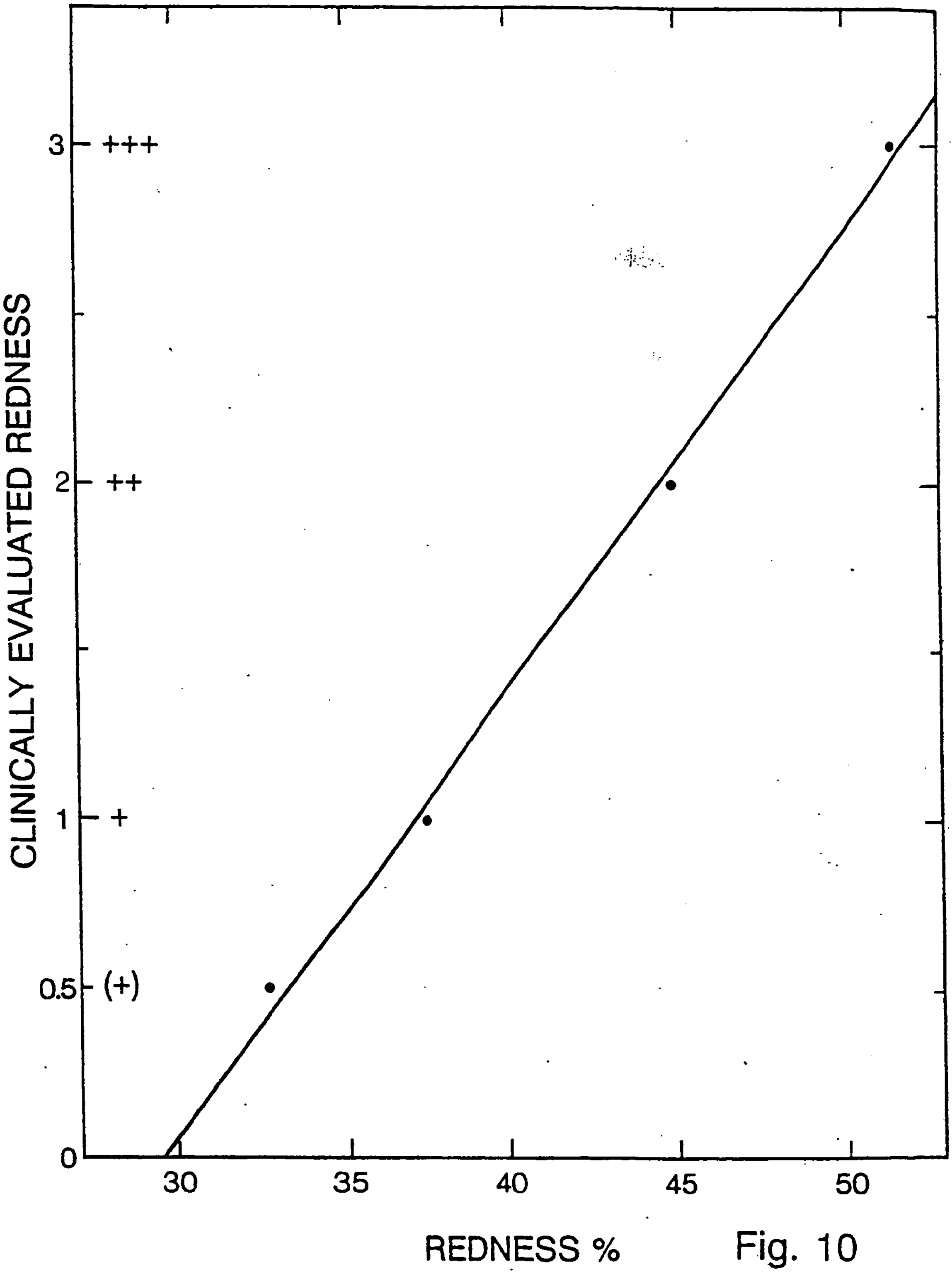


Fig. 10

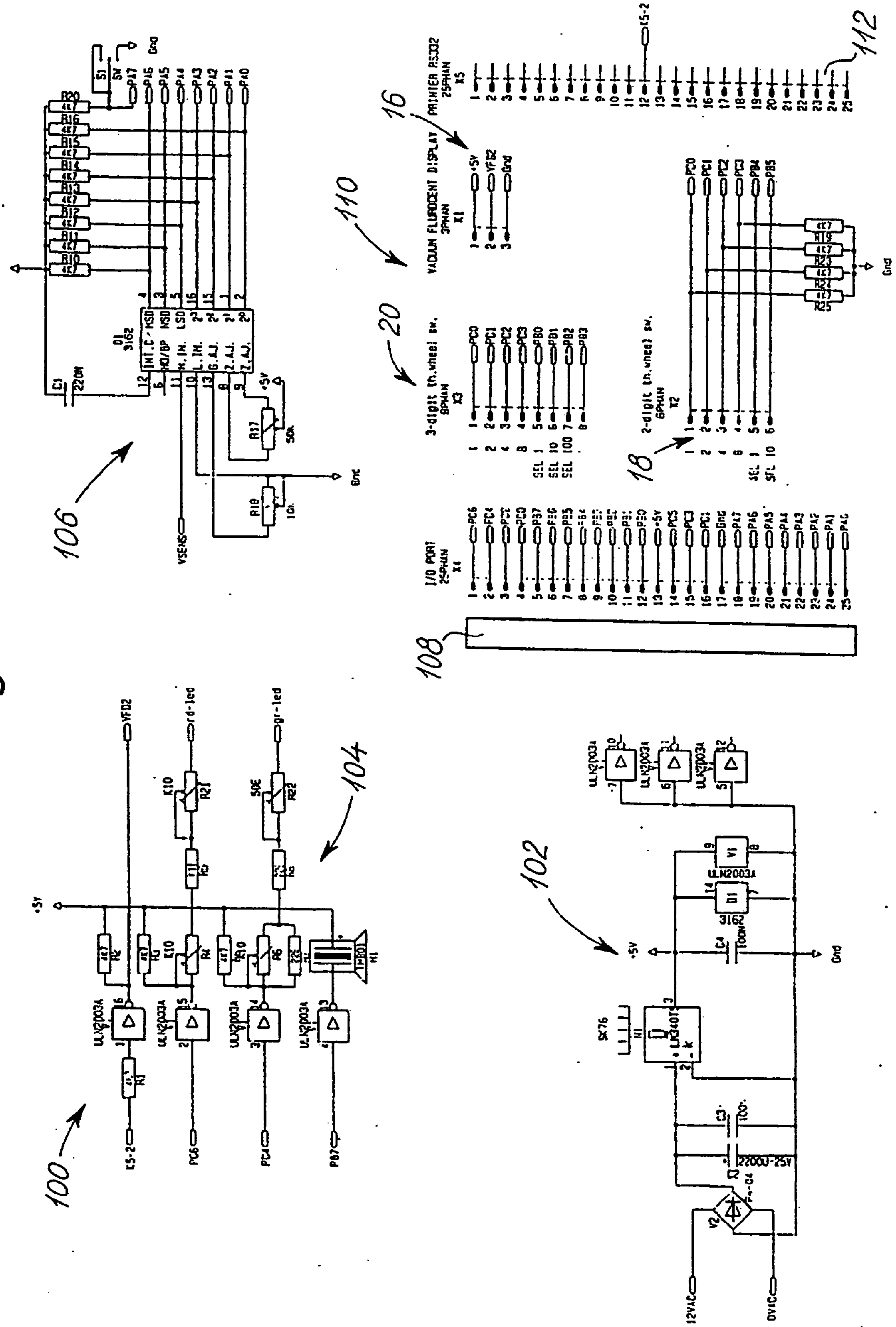


Fig. 11

13/22

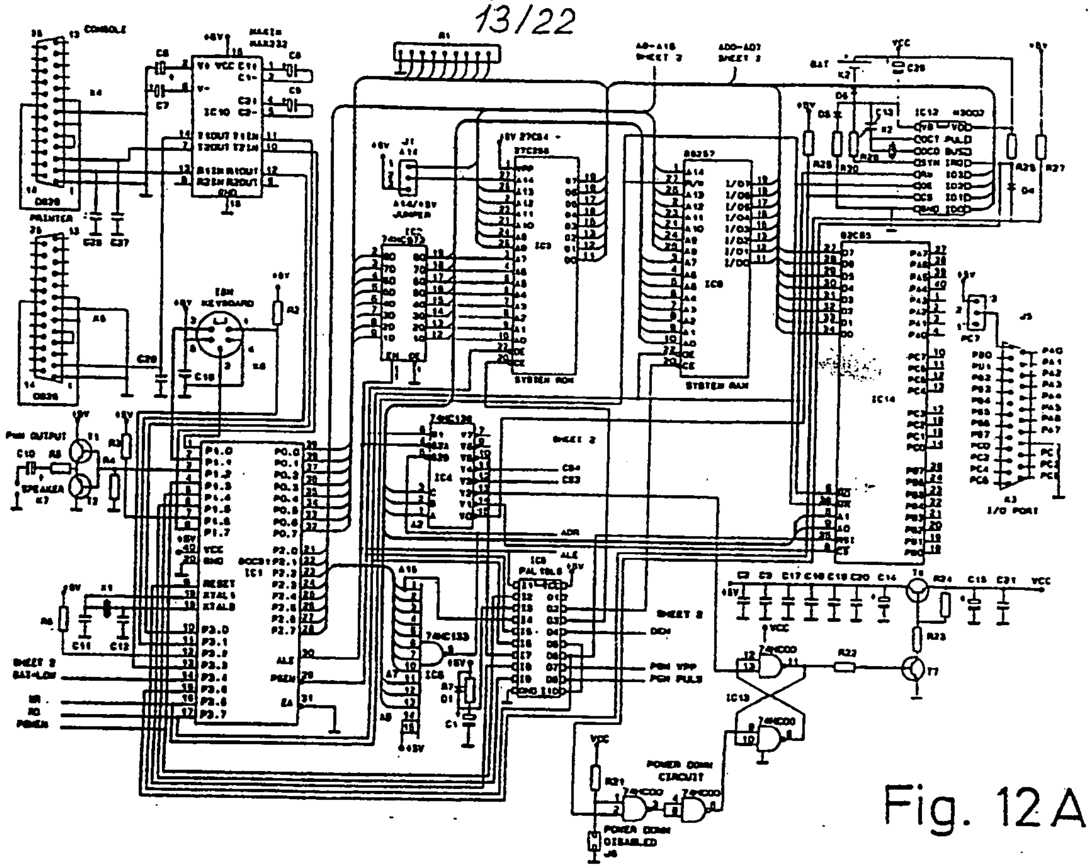


Fig. 12A

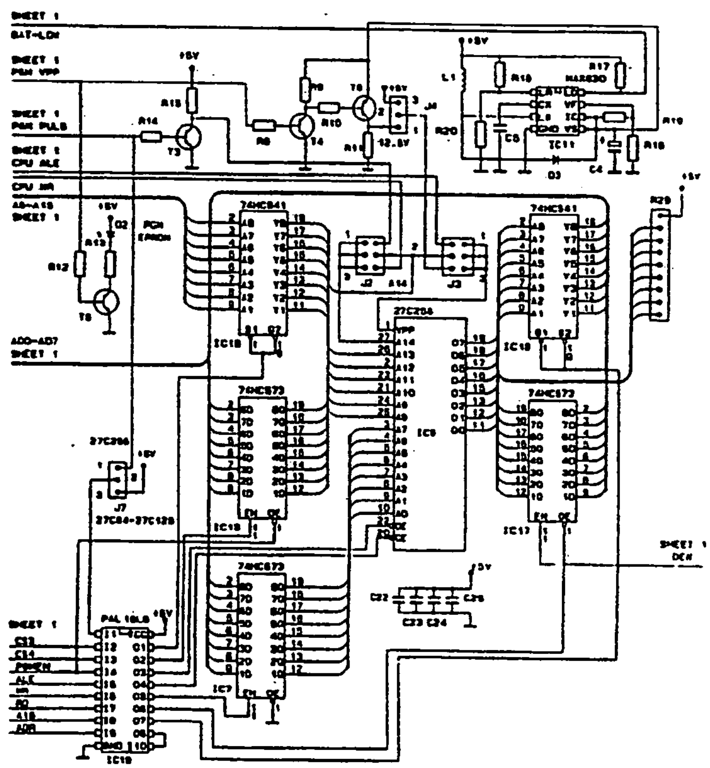
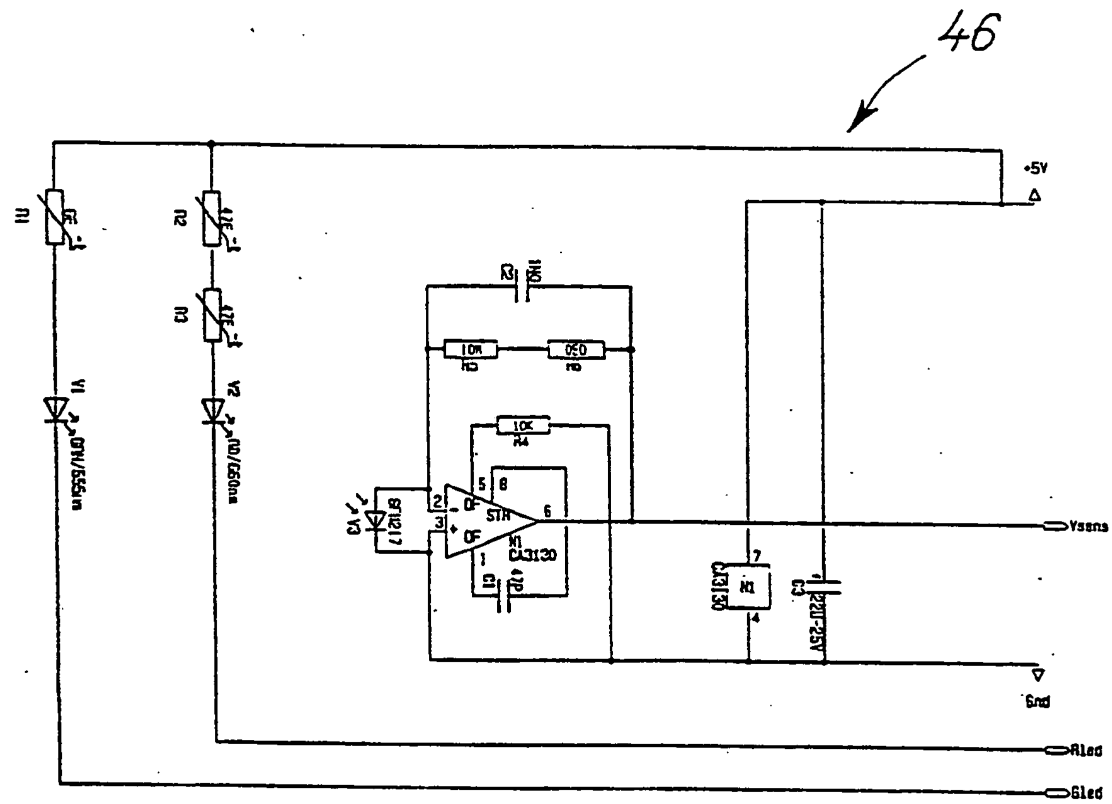


Fig. 12B

Fig. 13



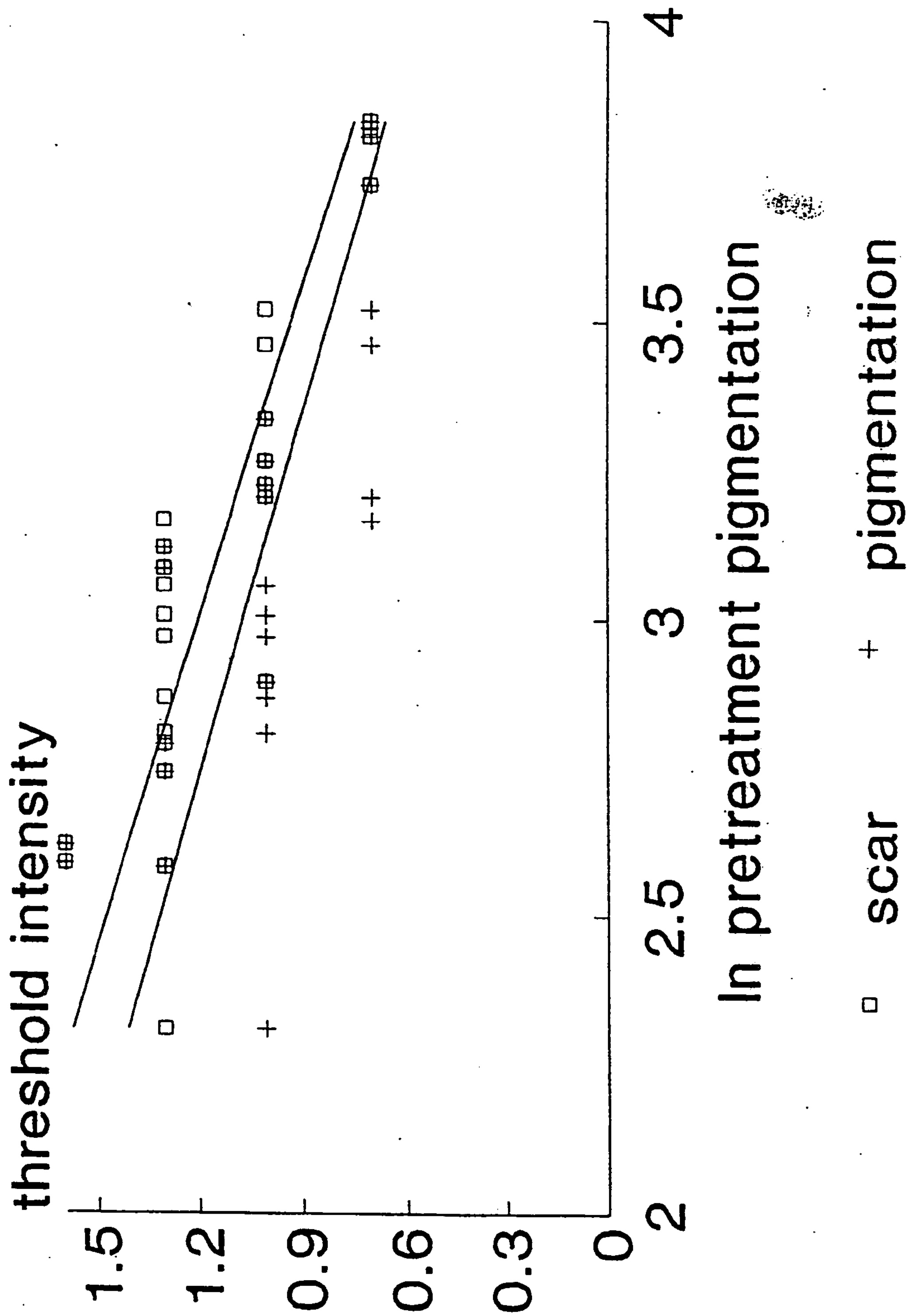

threshold intensity
1.5
1.2
0.9
0.6
0.3
0
2
2.5
3
3.5
4
ln pretreatment pigmentation
scar
pigmentation

Fig. 14

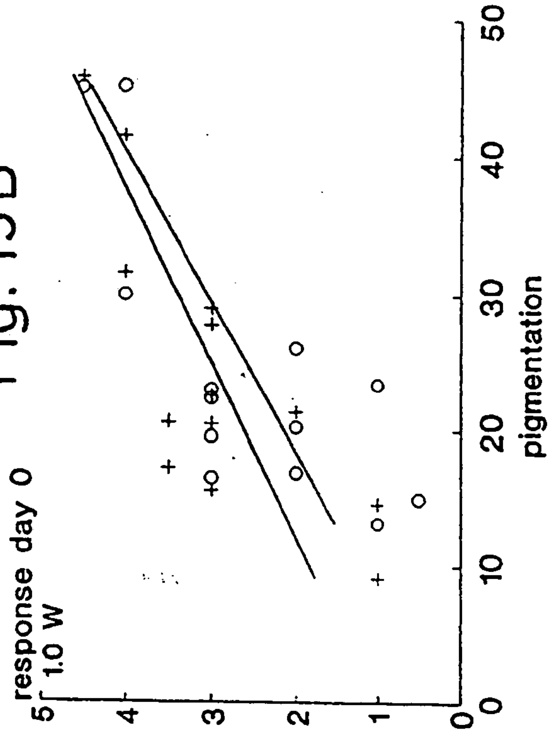
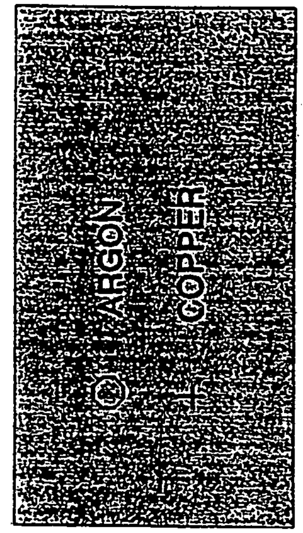


Fig. 15B



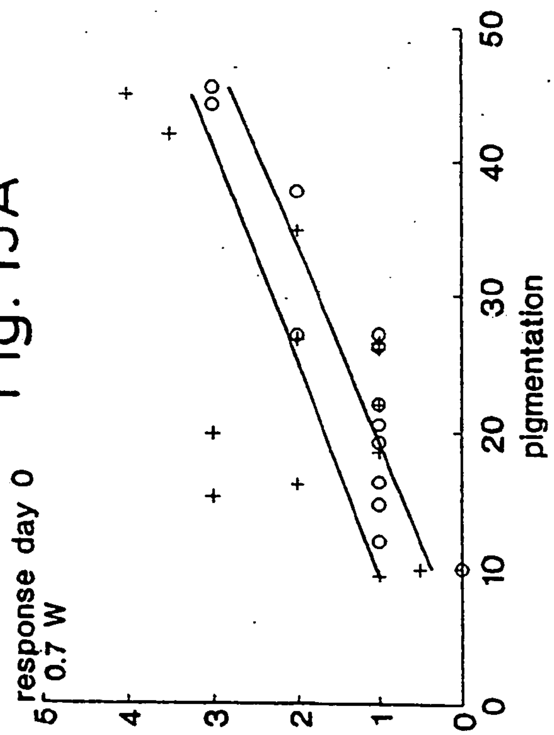


Fig. 15A

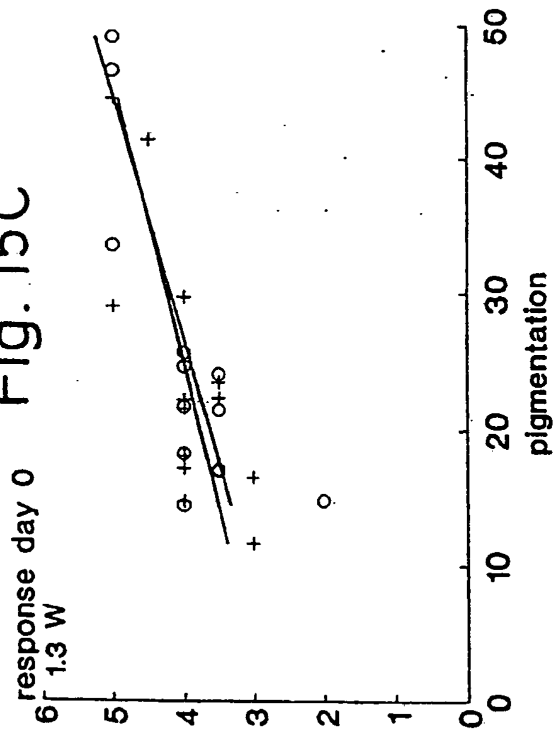
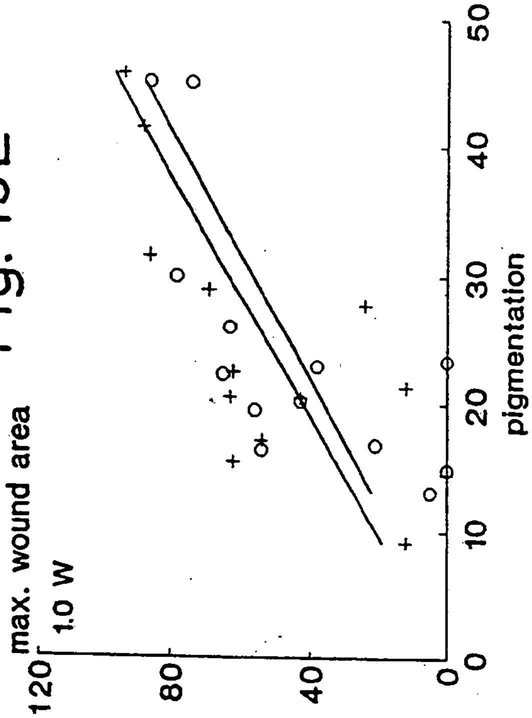


Fig. 15C

Fig. 15E



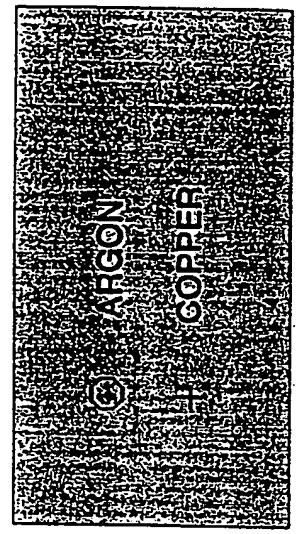


Fig. 15D

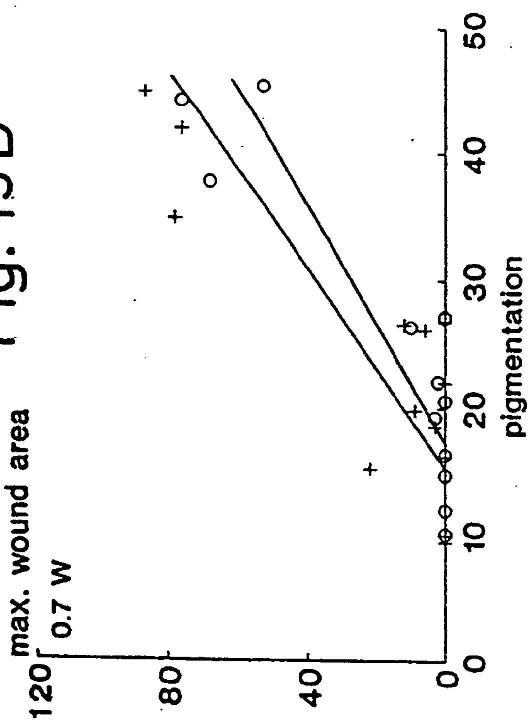
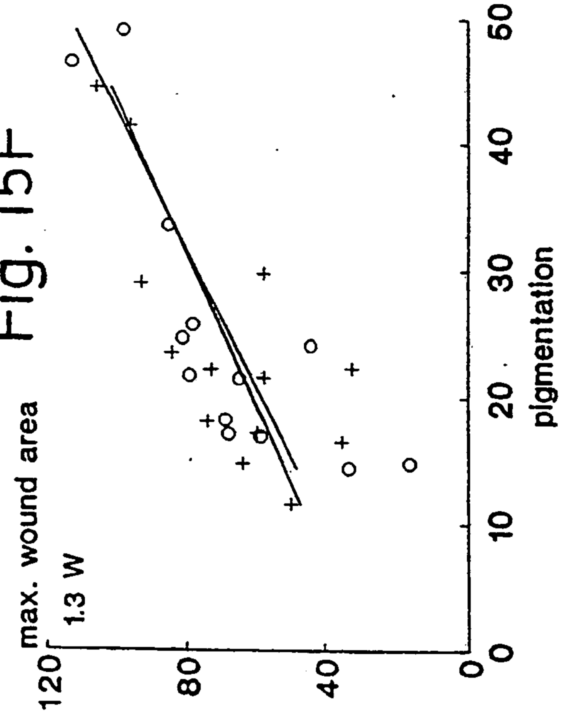


Fig. 15F



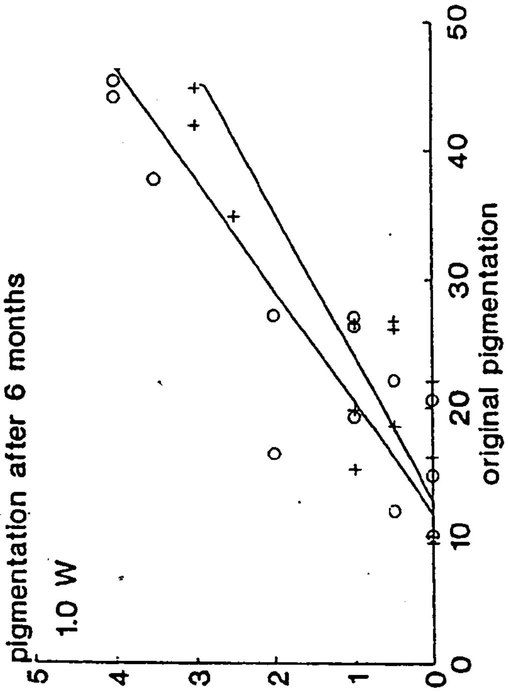


Fig. 15H

○ ARGON
+ COPPER

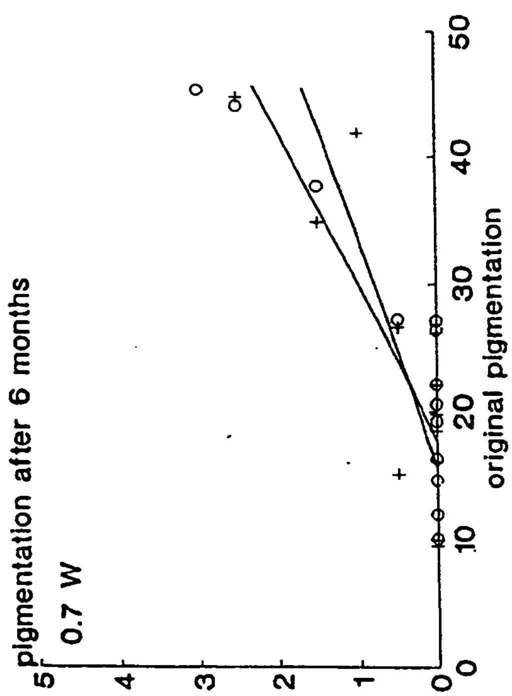


Fig. 15G

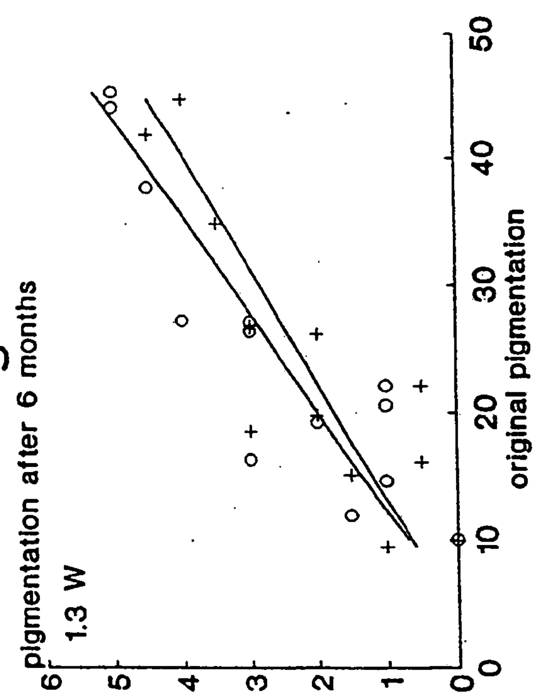
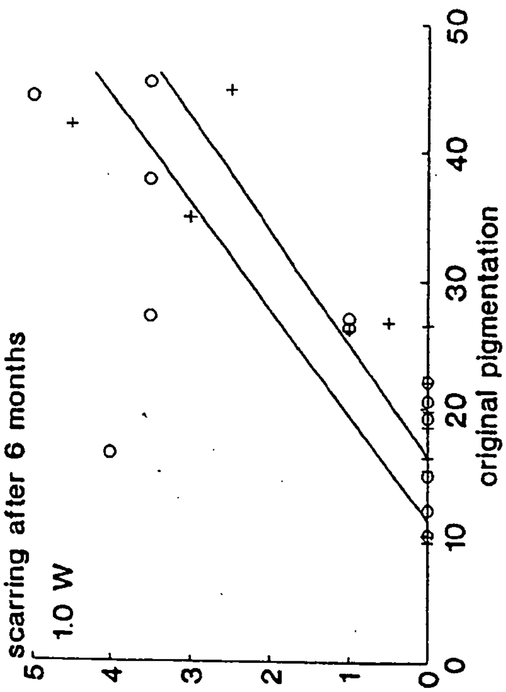


Fig. 15I

Fig. 15K



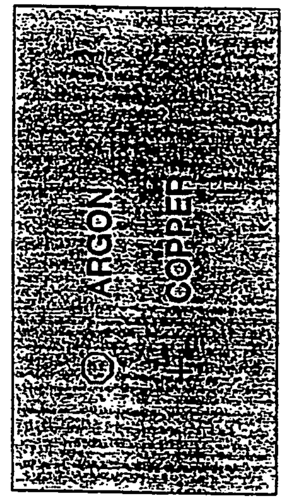


Fig. 15J

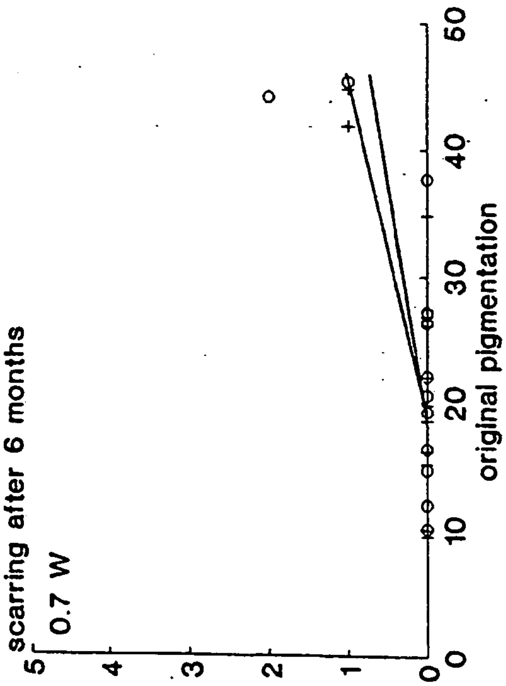
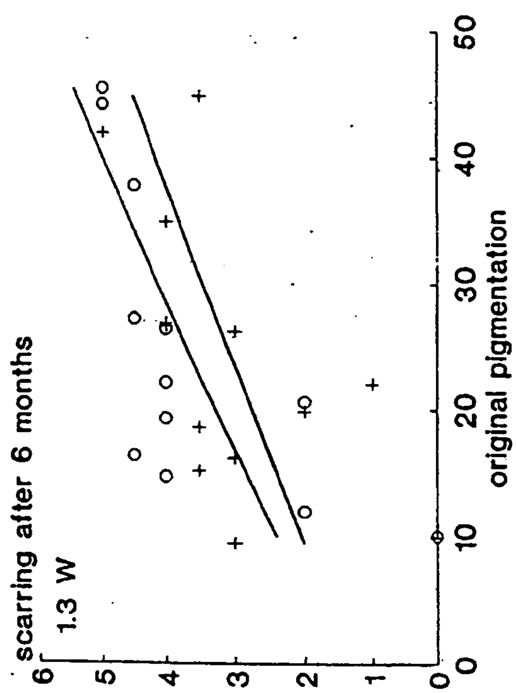


Fig. 15L



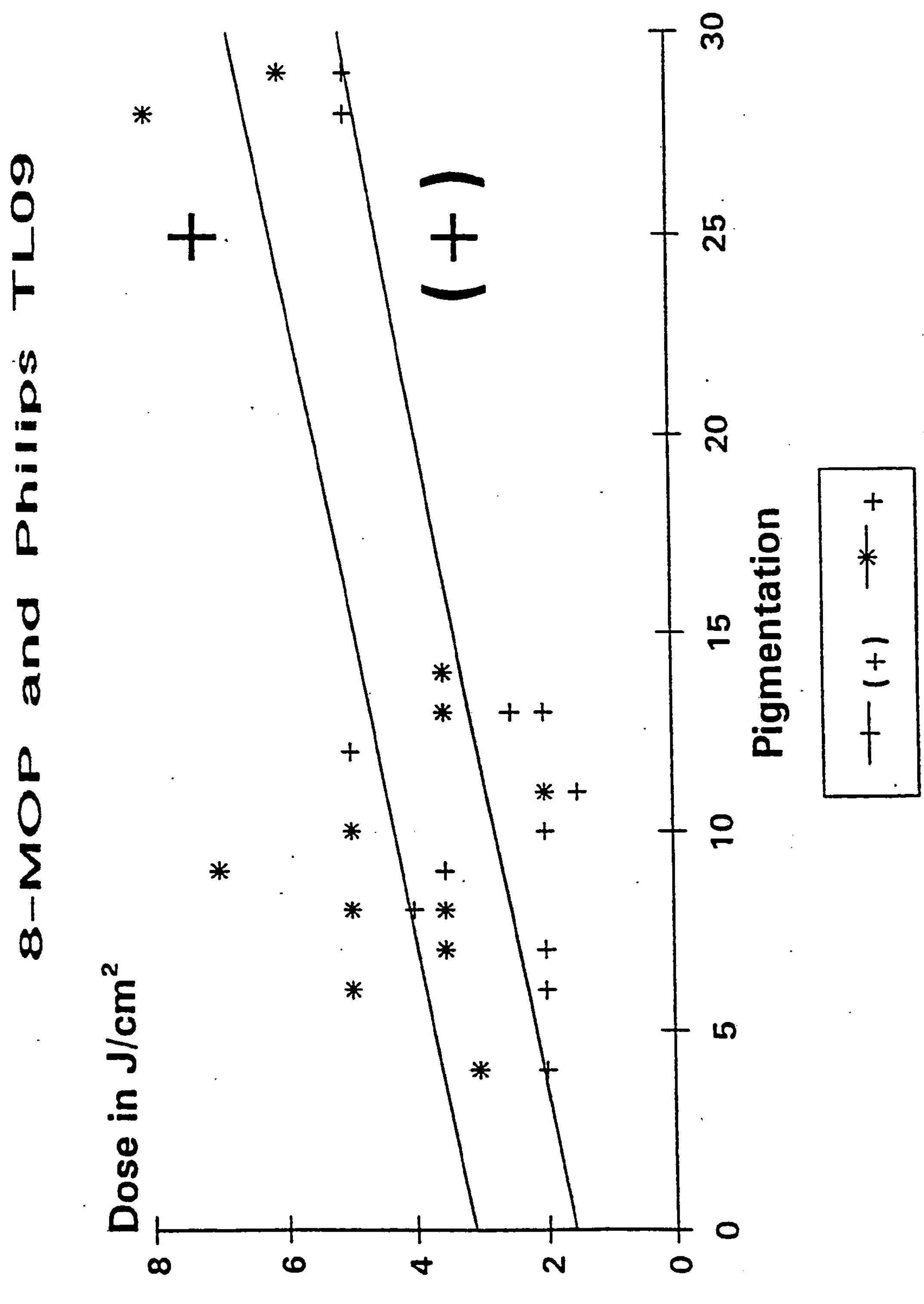

8-MOP and Philips TL09
Dose in J/cm²
+
(+)
Pigmentation
(+)
0
2
4
6
8
0
5
10
15
20
25
30

Fig. 16

Difference between experimentally found dose and calculated dose to reach a certain redness.

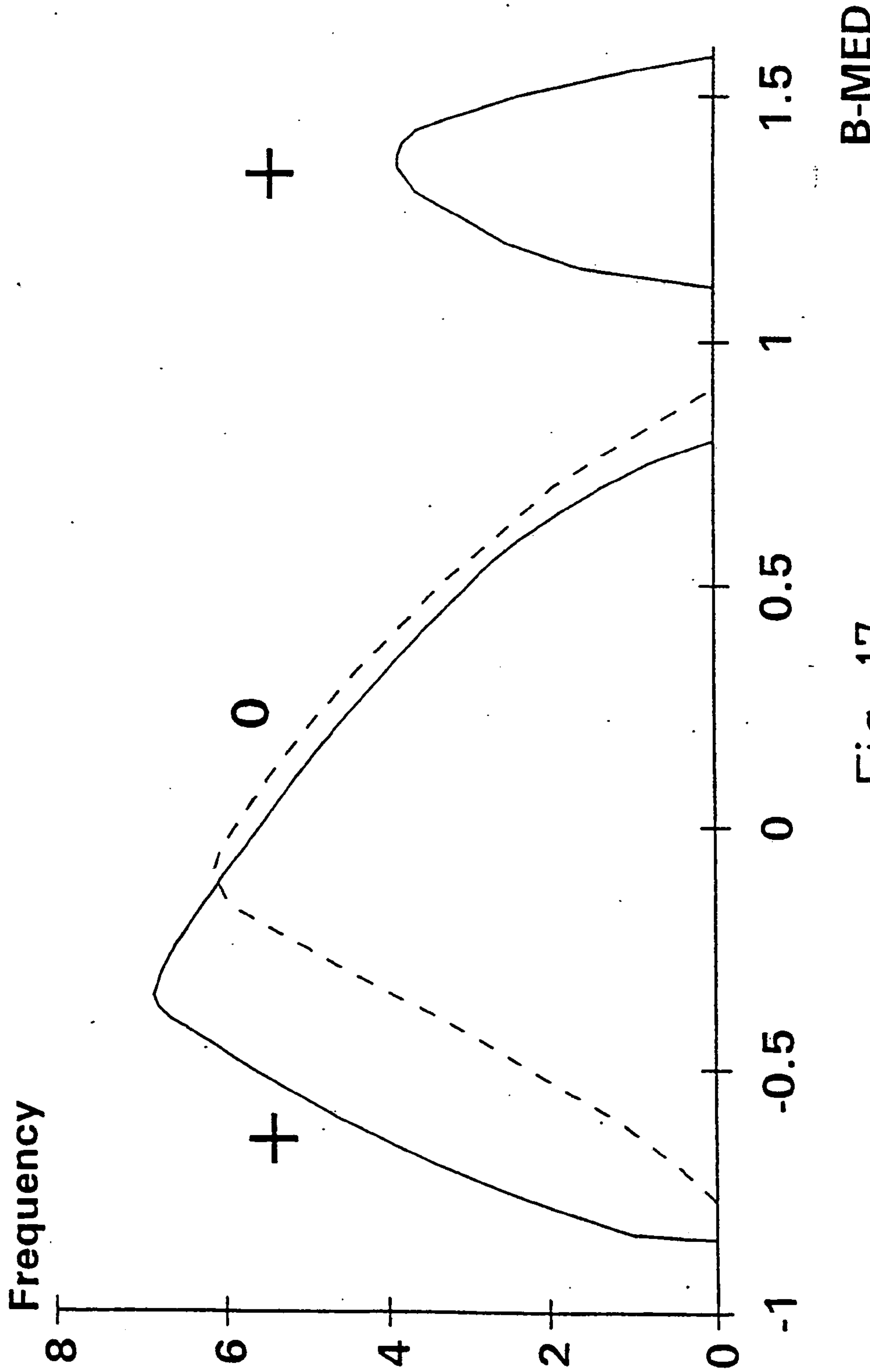


Fig. 17

Sensitivity compared to normal
in B-MED.

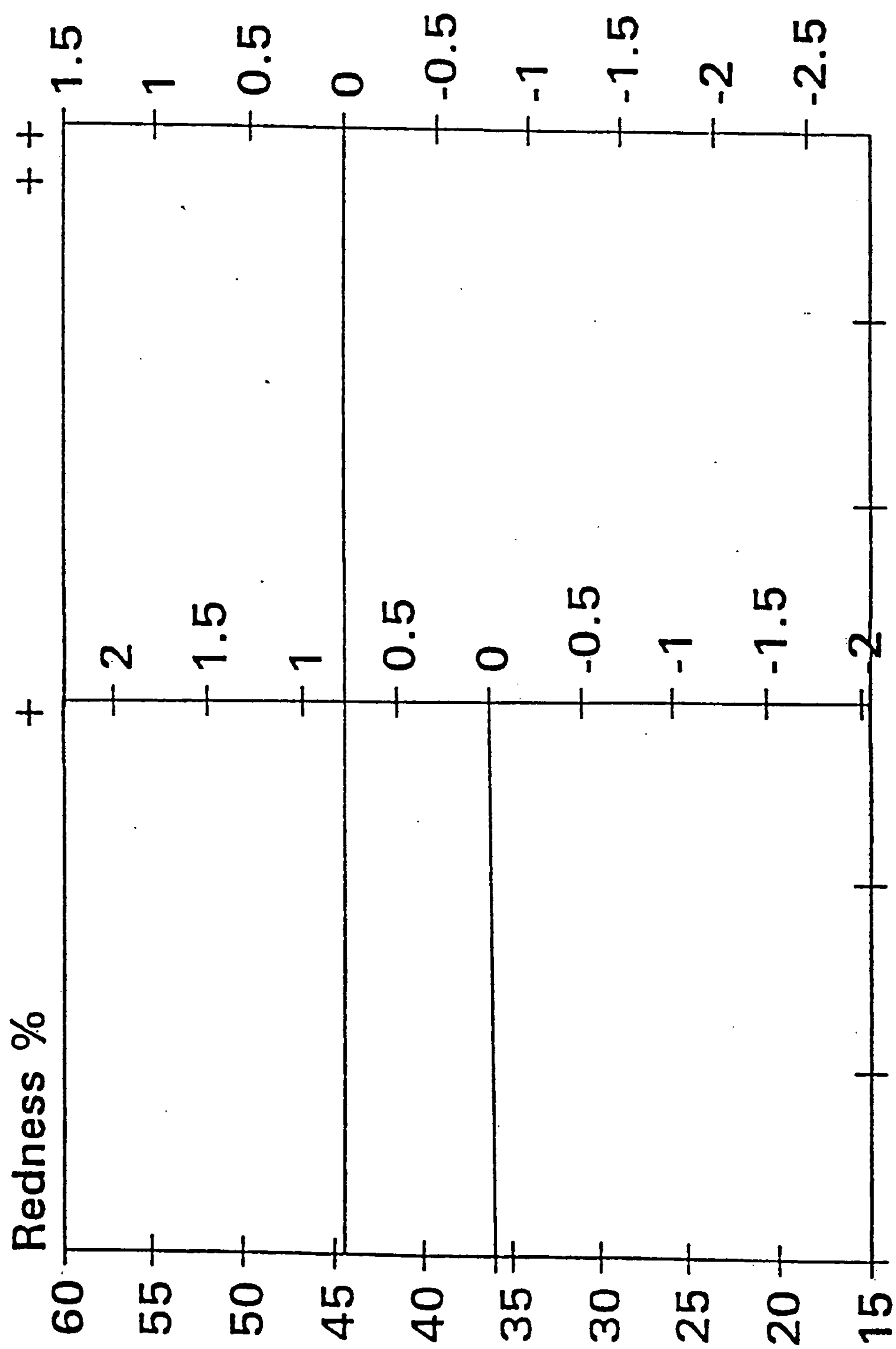


Fig. 18

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 93/00072

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: A61B 5/103, G01J 3/50
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: A61B, G01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4882598 (HANS C. WULF), 21 November 1989 (21.11.89), claim 6 --	1-10
A	US, A, 4423736 (DAVID P. DEWITT ET AL), 3 January 1984 (03.01.84), abstract --	1-10
A	US, A, 4749865 (KLAUS SCHELLER), 7 June 1988 (07.06.88), see the whole cocument --	1-10
A	US, A, 4846184 (ALAIN COMMENT ET AL), 11 July 1989 (11.07.89), see the whole document --	1-10

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
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"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 May 1993	01-06-1993
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Anders Holmberg Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 93/00072

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO, A1, 8805284 (NEWER S.A.), 28 July 1988 (28.07.88), see the whole document --	1-10
A	WO, A1, 9114159 (HENRIK LEMMING), 19 Sept 1991 (19.09.91), see the whole document -- --------	1-10

INTERNATIONAL SEARCH REPORT
Information on patent family members

31/03/93

International application No.
PCT/DK 93/00072

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4882598	21/11/89	EP-A- 0238574 WO-A- 8701948	30/09/87 09/04/87
US-A- 4423736	03/01/84	NONE	
US-A- 4749865	07/06/88	DE-A,C- 3506690 EP-A- 0193163	04/09/86 03/09/86
US-A- 4846184	11/07/89	EP-A,B- 0198759	22/10/86
WO-A1- 8805284	28/07/88	AU-A- 1104588 CH-A,B- 669325 EP-A- 0301042	10/08/88 15/03/89 01/02/89
WO-A1- 9114159	19/09/91	AU-A- 7468391	10/10/91